NASA TECHNICAL TRANSLATION NASA TT F-16536

PSYCHOLOGICAL PROBLEMS OF INTERPLANETARY FLIGHT

A. A. Leonov and V. I. Lebedev

(NASA-TT-F-16536) PSYCHOLOGICAL PROBLEMS OF INTERPLANETARY FLIGHT (Joint Publications Research Service) 236 p HC $8.00 CSCL 16S

N76-16750

Unclas

G3/52 13643

Translation of "Psikhologicheskiye problemy mezhplanetnogo poleta," Moscow, Izdatel'stvo Nauka, 1975, pp 4-248

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 OCTOBER 1975

STANDARD TITLE PAGE

1. Report No. NASA TT F-16536	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PSYCHOLOGICAL PROBLEMS OF INTERPLANETARY FLIGHT		5. Report Date October 1975
		6. Performing Organization Code
7. Author(s) A. A. Leonov, V. I. Lebedev		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Joint Publications Research Service Arlington, VA 22201		11. Contract or Grant No. W13,183-197
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Psikhologicheskiye problemy mezhplanetnogo poleta," Moscow, Izdatel'stvo Nauka, 1975, pp 4-248

16. Abstract

The monograph examines the questions of psychological compatibility among crew members of an interplanetary ship under the conditions of group isolation, the extended effect of weightlessness on human mental processes, the effect of sensory and information starvation on the appearance of unusual mental states, emotional stress, and the rhythm of working and rest.

17. Key Words (Selected by Author(s))	18. Distribution Statement Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	236	

PSYCHOLOGICAL PROBLEMS OF INTERPLANETARY FLIGHT

Moscow PSIKHOLOGICHESKIYE PROBLEMY MEZHPLANETNOGO POLETA [Psychological Problems of Interplanetary Flight] in Russian 1975 pp 4-248

[Book by A. A. Leonov and V. I. Lebedev, edited by Prof B. F. Lomov, Izdatel'stvo Nauka, signed to press 21 May 1975, 7,300 copies]

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ANNOTATION

The monograph by the USSR Cosmonaut-Pilot A. A. Leonov and Candidate of Medical Sciences V. I. Lebedev is devoted to a very complex and still little studied problem of the psychology of an interplanetary flight. The monograph examines the questions of psychological compatibility among the crew members of an interplanetary ship under the conditions of group isolation, the extended effect of weightlessness on human mental processes, the effect of sensory and information "starvation" on the appearance of unusual mental states, emotional stress, and the rhythm of working and rest. In their book, the authors make wide use of the results of observations and self observation of cosmonauts during space flights, subjects in experiments on ground stands, and well as the researchers of inaccessible regions of the world.

The book is designed for cosmonauts, psychologists, psychoneurologists, philosophers, as well as a broad range of specialists working in the area of cosmonautics.

FOREWORD

The solving of the greatest problem of mankind--the conquering of space--has been possible only on the basis of using the achievements of many sciences. In tracing the path into space, it is easy to see that constantly new areas of scientific knowledge have joined this path. The launching of the first earth satellite was a triumph of technical and physicomathematical sciences. Precisely these sciences solved the involved complex of questions related to the creation of spacecraft. Soon thereafter, when the question was posed of launching a living being into space, biological sciences also joined the complex of technical sciences. The biological sciences were to answer the question of how the functioning of the physiological systems of the organism is altered under the conditions of a spaceflight.

The flight of the Hero of the Soviet Union, cosmonaut-pilot Yu. A. Gagarin (the first flight of a spacecraft with a man on board), marked the beginning to a new stage in the conquering of space, and at this time the sciences dealing with man became involved in the research program. Initially these were the medical and biological sciences and later on the psychological ones. It is important to point out that the more complicated the functions a cosmonaut masters, the greater the significance assumed precisely by psychological research. When it is an issue of a manned flight, we are interested primarily in such questions as whether he can work actively under the specific conditions of space; how these conditions influence perception and attention, the memory and thinking of man, and his conscious purposeful activities; what changes in the psyche can arise as a result of an extended stay in an enclosed space, overloads, weightlessness, and so forth.

The preparation of interplanetary flights necessitates the development of research in essence in all the basic directions of psychological science, including: labor psychology which studies how the labor activity of man is organized, of what elements it is composed, and how the conscious arbitrary regulation of labor actions and working movements is carried out; human-factors engineering which investigates the process of the information interaction of man with technical devices in control systems, and on this basis studies the questions of adapting technology to man; social psychology which examines the relationships of people in working groups, the formation of labor collectives, the dynamics of human intercourse in the joint activities of people; educational psychology which studies the processes of the formation of knowledge, abilities and skills, and the development of capabilities, character and will. The complex of these directions also includes psychophysiology, neurophysiology, psychophysics, medical psychology and a number of other psychological disciplines.

Psychological research on interplanetary flights certainly, like any other research, should become many-leveled and comprehensive. In preparing for such flights, the question of planning for the life and activities of the cosmonauts becomes particularly urgent. It is essential to conceive ahead of time, before the flight, and in as great detail as possible, those conditions under which the people will live and work and to prepare them for these conditions. Here we encounter a very important and complicated problem of "designing" the way of life of people who will remain under specifically difficult conditions for a long time.

The offered book by the Hero of the Soviet Union, cosmonaut-pilot A. A.Leonov, and Candidate of Medical Sciences V. I. Lebedev is a first attempt to analyze the essence of the psychological problems arising under the conditions of an interplanetary flight, to describe the way of life of the cosmonauts under these conditions. and to outline certain lines of research aimed at preparing for an interplanetary flight. The book is devoted to the long-range problems of space psychology.

Understandably, in writing such a book, the authors have encountered great difficulties. They had to describe what as yet no one has ever observed, but what on the basis of the existing scientific knowledge could be foreseen. In solving this difficult problem, the authors have made skillful use of the materials acquired in various areas of psychological research. This includes the data of experiments and observations on the behavior of a man under various conditions, more or less similar to those which will arise in an interplanetary flight.

In a certain sense, this book could be described as science fiction. But, of course, this is not a science fiction novel, but rather a scientific work. It examines the problems of psychological science, and gives the research results, but these results have been aimed not at the past or at the present, but rather at the future.

Of course, in this book not all the authors' conclusions are uncontestable, and not all the questions have been examined in sufficient profundity. However, the main merit of the book is that it poses new questions for psychological science, and commences a debate on the development prospects of one of its young areas, space psychology.

Prof B. F. Lomov

INTRODUCTION

> I believe in the brilliant future of mankind, I believe that mankind not only has inherited the earth, but is also to transform the world of the planets. From here, from the solar system, will begin the migration of mankind throughout the Universe. I am profoundly convinced of this. This is the destiny of man. He should transform many planetary systems.
>
> K. Tsiolkovskiy

No scientific and technical sector has developed as rapidly as cosmonautics. Since the launching of the first earth satellite on 4 October 1957 up to the present, many difficult problems have been solved, and this makes it possible to expect that over the next few decades, a qualitative shift will occur in the conquering of space, that is, the era of interplanetary flights will commence.

One of the intermediate stages on the way to interplanetary flights is the creation of permanent orbital stations. At a meeting with the crews of the Soyuz-6, Soyuz-7 and Soyuz-8 spacecraft, the General Secretary of the CPSU Central Committee, L. I. Brezhnev, said about the orbital stations: "Soviet science views the creation of orbital stations with rotating crews as the main path of man into space. They can become the 'cosmodromes in space,' and the launching pads for flights to other planets. Large scientific laboratories will arise for examining space engineering and biology, medicine and geophysics, astronomy and astrophysics."[1]

In the USSR, on 19 April 1971, the first extended-life scientific space station, the Salyut, was launched into space. This station functioned successfully for around 6 months, until 11 October 1971. For almost 24 days, a crew consisting of the cosmonaut-pilots G. T. Dobrovol'skiy, V. N. Volkov and V. I. Patsayev worked on board. During this flight, a large amount of scientific-technical, medico-biological, physics, astrophysical and other research was carried out.

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1. PRAVDA, 23 October 1969.

On the American Skylab, in 1973, three crews were changed. In 1974, in the USSR, the orbital station Salyut-3 was launched, and the crew consisting of cosmonaut-pilot of the USSR P. R. Popovich and flight engineer Yu. P. Artyukhin worked for 15 days. The crew consisting of cosmonaut-pilot A. A. Gubarev and G. M. Grechko spent a month on the Salyut-4 orbital station. The experience of the flights on the orbital stations significantly broadened our knowledge on the possible limits of the protracted stay of man in a state of weightlessness, his ability to work under space conditions, as well as the psychophysiological mechanisms of readaptation to terrestrial conditions upon returning to the earth.

At present, the design bureaus are creating the plans for stations which will remain in orbit not for months and not for years, but rather for entire decades. These orbital stations are to be put up from sections and blocks delivered from the earth by rockets. Each section can represent, for example, a specific type of laboratory or a crew compartment, and have the equipment which after the assembly of the station will become a component of the general power-supply or life-support system. Such a possibility was shown for the first time in the linking up of the Soviet Soyuz-4 and Soyuz-5 spacecraft in 1969.

On the orbital stations, there will be powerful telescopes, antenna arrays for radioastronomic observations and various scientific research equipment. From here superlong distance radio contact will be maintained with the interplanetary devices. In contrast to the space communications radio stations located on the earth, here there will be no interference. The use of lasers provides broad opportunities for communications over very great distances. The transport spacecraft will deliver people here for periodically changing the crew of the station. The movie theaters, libraries, hothouses and sports facilities will bring the life of the inhabitants of these stations close to ordinary life on the earth. Thus, the dream of K. E. Tsiolkovskiy about "ether cities" is being embodied in reality in our days.

In using just one carrier rocket, an interplanetary ship designed for a long voyage obviously cannot be put into orbit around the earth, and for this reason rockets with assemblies and the individual major parts of an interplanetary ship must be delivered to the "cosmodrome in space." The ship itself will be assembled at the "ether city." Its assembly in orbit necessitates various types of assembly work, including electric welding. For the first time in the world, an experiment of carrying out welding in space was achieved by the crew of the Soyuz-6 spacecraft consisting of cosmonaut-pilot G. S. Shonin and the flight engineer V. N. Kubasov.

After the assembly work at the orbital station, the ship will have to be fueled and supplied with food products and other necessary cargo. Then the members of the expedition preparing for a flight to Mars or other planets will arrive at the station. It is at the station that they will undergo unique acclimation and "settle in" before the long voyage. Naturally the question arises of when all of this will occur?

Forecasting the development of any sector of science and technology should be based upon the experience of the past. Only on the basis of considering the development trends of a specific sector of technology or science, the needs of practice and other factors is it possible to make an extrapolation into the future.

The first attempt at forecasting the development of cosmonautics for the next 35 years, on the basis of considering the designated factors, was made in 1966 at the Fourth Symposium of the American Astronautics Society. The papers of the participants of this symposium were made into the collection "The Space Era. Forecasts to 2001."[1]

In the opinion of the American scientist /K. A. Erike/ who spoke at this symposium, in 1982-1985, a permanently operating scientific laboratory will be created on the moon. The flight to Mars, this scientist is convinced, will be made in the middle of the 1980's. An analogous prospect for the conquering of space was made by the American scientist /V. G. Pardy/ in his paper. In his opinion, in 1975-1980, long-existing, manned space stations in near-earth orbit will be created, and in 1980-1990, a manned lunar observatory and automatic observatories in various areas of the solar system. A manned flight past Venus, in his opinion, will take place in 1980-1985, and the same flypast of Mars in 1985-1990. He assumes that the landing of an expedition on the surface of Mars will occur in 1990-2000.

Over the 9 years which have passed since this symposium, the forecasts have been significantly sharpened up, and up to the present, the prospects of interplanetary flights over the next two decades are much more definite. Of great significance were the flights of the American astronauts made under the Apollo Program. Thus, the first journey between two celestial bodies was made in December 1968 by F. Borman, J. Lowell and W. Anders who made a flight around the moon. The first expedition of man to the moon was made in July 1969 on the Apollo-11 spacecraft with a crew consisting of the astronauts N. Armstrong, M. Collins and E. Aldrin. The lunar module with two astronauts made a soft landing. Photographs were taken on the moon, and samples of the lunar ground were taken. A liftoff from the lunar surface was executed, and then, having linked up with the mother ship, the crew returned to the earth.

In turning to the history of manned flights to the moon, it must be pointed out that Soviet automatic stations blazed the trail to our natural satellite. On the day that Apollo-11 landed on the lunar surface, the American UPI Agency correctly wrote: "We must not forget the achievements of the pioneers of the conquering of space who provided the information which made this remarkable achievement possible. The first satellite was a Soviet one. The first people in space were Russians. All the basic achievements in space were done in the USSR...."

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1. "Kosmicheskaya Era. Prognozy na 2001 God," translated from the English, Moscow, Mir, 1970.

At a meeting with Soviet cosmonauts at Zvezdnyy Gorodok [Star Town], the commander of Apollo-8, Frank Borman, said: "Your satellite caused me to think about space, and lit the spark of questing. The flight of Yuriy Gagarin who was the first to blaze the trail to the stars became an unexcellable event of the century.... I am hopeful that the days of my visit with you would bring our cooperation closer in space research. In your country, I have been amazed by the enormous scope of scientific and technical work in the most different areas...." [77, pp 7-8].

As for the interplanetary automatic stations, it can be said that at present they are successfully blazing the trail for mankind to the planets of the solar system. The first research device directed toward another planet was the Soviet Venera-1 [Venus] interplanetary automatic station which was launched in February 1961. In subsequent years, several stations of this same series have been sent off toward Venus. As a result of processing the information obtained from the interplanetary stations, it was established that the planet Venus possesses a thick, dense atmosphere consisting basically of carbon dioxide, and close to the surface has very high pressure (140 atm) and temperature (530°) readings. Thus, it was established that in the next few years it will not be possible to land an expedition on the surface of Venus.

In November 1962, the first Soviet interplanetary automatic station Mars-1 was launched toward Mars, and in November 1964, the Zond-2 space device was launched in the USSR toward Mars. In the United States, the Mariner-4 spacecraft was launched toward Mars, and later on, in 1969, Mariner-6 and Mariner-7.

Judging from the information received from the interplanetary automatic stations of the Mars series, this planet is amazingly similar in its landscape to the moon. Here, as on the moon, it is deserty and there are many craters. The atmospheric pressure does not exceed several millibars.

The study of Mars and Venus using automatic interplanetary stations is being successfully continued. However, Yu. A. Gagarin has written: "The future of cosmonautics is difficult to represent without manned devices. It is inconceivable to develop and conquer space with just automatic stations. They, undoubtedly, do tell and will tell a great deal, but, in my view, these stations are only the first step in the advance into space. Only man can sustain the victory and keep what has been won" [36, p 30].

The first manned spaceflight made by Yu. A. Gagarin lasted just 108 minutes. A flight to the planet Mars over a trajectory with minimal energy expenditures will last 259 days. In orbiting around this planet, the cosmonauts will have to wait 450 days for a favorable interpositioning of Mars and the earth. The entire journey to there and back will take 968 days (2 years and 8 months). By increasing the speed of injecting the ship into the interplanetary trajectory, the total time of the journey can be reduced to 400 days.

The development of manned interplanetary flights confronts science and technology with a number of problems related to the need of creating conditions for the normal functioning of the human organism, for providing normal working and resting conditions, as well as maximum consideration of the specific factors which affect the psyche of the cosmonauts.

Up to now a significant number of publications (articles in collections and journals as well as monographs) have been accumulated on the psychophysiological problems of a spaceflight. Their authors (engineers, physicians, biologists and other specialists) due to their specialty treat specific questions related in one way or another to spaceflight. But the authors of this book have set as their task the systematizing of existing material, and on this basis, the providing of the reader with a general notion of the psychological problems of a long interplanetary flight.

Undoubtedly, the experience of orbital flights and simulating experiments will in the future make corrections in these problems. The very practice of interplanetary flights can disclose phenomena which at present we are totally ignorant of.

Nevertheless, the authors hope that the present book will be useful both for specialists working directly in the area of cosmonautics (physiologists, psychologists, physicians and philosophers) as well as for specialists in the area of fundamental and applied sciences whose activities are indirectly linked with the actual conquering of space.

Since the book is designed for a broad range of specialists, the authors not only have stated the discovered patterns, but also bring in the phenomenological material making it possible for the reader to "sense" the life of people living under extremal conditions. For this, extensive use has been made of the results of observations and self-observations of the cosmonauts, testers and researchers of inaccessible regions of the world. Moreover, we feel that the facts given in the book (in particular, the phenomenological descriptions) will make it possible for the specialists to interpret them in their own way, and this, in turn, can lead to a discussion contributing to the development and successful solution of the problems of long spaceflights.

In a number of instances the authors have taken up not only purely psychological questions but also psychoneurological ones. And this is understandable as we often encounter facts of neurotic breaks in examining the life of people under extremal conditions, that is, such conditions when a person is working at the limit of his physical and mental capabilities.

CHAPTER I: THE CREW OF AN INTERPLANETARY SHIP

Analysis of the psychological problems of an interplanetary flight can be started with the following practical question: How many specialists should there be in the crew of the first interplanetary ship? Here, obviously, one must proceed from the particular features of the design of the interplanetary ship and those missions which the crew members will carry out.

An interplanetary ship is a complex technical apparatus the design of which incorporates scores of major systems, each of which will consist of thousands of different units, assemblies and parts. For servicing an interplanetary craft, in the opinion of K. P. Feoktistov, "it will be necessary to have from 50 to 100 various specialists on board." At the same time, "in order to keep within certain acceptable weight limits, considering the consumption of food and water, it is difficult to imagine an expedition of such size" [206, p 43].

In the opinion of many scientists working in the area of cosmonautics, this problem can be solved by training universal specialists, each of whom will be able to operate not one but several systems of a certain type (direction) on a highly skilled level.

What directions of the systems can be established in the design of an interplanetary craft?

The takeoff, maneuvering in space and the landing of the module on the planet are carried out by jet engines. At present, jet engines operate on a chemical fuel. Although interplanetary flights are possible using rockets operating on chemical fuel, it is not excluded that by the time of these flights, jet engines operating on atomic energy will be developed. On present-day spacecraft, batteries, chemical cells and solar batteries are used as the source of electric energy. On interplanetary ships, aside from the listed sources, they will obviously use small-sized nuclear power units for these purposes.

While the jet engines during the flight are fired periodically, the power units for supplying the various systems of the ship with electric energy must operate constantly.

Thus, control over the operation of the jet engines and all the power systems of the ship should become the duty of one of the crew members, a widely specialized power engineer.

K. P. Feoktistov was the first specialist given the mission of observing the work of the ship's systems and carrying out a number of scientific experiments in space. He received his engineering education at the Moscow Higher Technical School imeni Bauman.

After defending a dissertation, K. P. Feoktistov worked in a group of scientists and designers concerned with the development and creation of space systems. In preparing directly for a flight at the Cosmonaut Training Center which now bears the name of Yu. A. Gagarin, he successfully mastered a number of procedures for carrying out scientific experiments in space, and "orders" from many scientific research institutes were given for these. In occupying the chair of the engineer and researcher of the Voskhod spacecraft, Feoktistov knew perfectly all the systems and equipment of this ship, and was ready to conduct an entire complex of scientific research.

A. S. Yeliseyev, V. I. Sevast'yanov and other flight engineers of the spacecraft received the same all-round training. They took a direct part in the design developments and testing of various spacecraft systems. They had completed scientific works on the given problems. Combined with special training at the Cosmonaut Training Center, this allowed them to acquire profound, all-round knowledge about the design of the ship and the work of its systems.

In the orbital flights, the functions of the navigator were performed by the ship's commander. In our opinion, on an interplanetary ship, a navigator-engineer should be the second crew member. His duties will include the constant determining of the location of the ship in interstellar space, the forecasting of its movement along the calculated route, and the prompt making of corrections in the flight trajectory. Even in instances of insignificant errors in calculating their coordinates and the delayed making of corrections, the flight could terminate tragically. Here is what has been written by the director of the English radioastronomy observatory, J. Lovell, on the consequences of the inaccurate calculation of the trajectory upon the return of the Apollo spacecraft from the moon to the earth: "If the spacecraft enters the dense layers of the atmosphere at too great an angle, it will burn up. If the angle, on the contrary, is too slight, the spacecraft will break out of the atmosphere and be lost forever in space" [40, p 113].

Indicative in this regard is the experience of the Apollo-8 spacecraft which made the first flight to the moon. When the ship went into the last selenocentric loop before returning to the earth, contact with Mission Control was interrupted. Apollo was flying above the backside of the moon. An American TV correspondent, in interrupting the broadcast, stated: "We will meet you again at 0100 hours. By that time, we will know whether the engine of Apollo-8 has fired. If it has fired, the astronauts will return to earth. If not, they will remain satellites of the moon forever" [56, p 115]. At the end of the calculated time, the situation was very anxious at Mission Control. The operator continuously called Apollo-8. Space did not answer.

Apollo-8 appeared unexpectedly in the airwaves. "We have fired the engine," transmitted the commander, "as was set by the program. It fired normally! The ship is returning!"

The engine fired 198 seconds (according to the program, 195 seconds had been allotted). The increase in speed had to be compensated for during flight trajectory corrections. When 5,000 km had been covered, the astronauts made navigation measurements. The trajectory was close to the calculated.

During the flight, two other trajectory corrections were made. The last navigation measurements were made at a distance of 77,000 km from the earth.

Upon approaching the earth, the landing device was separated. It automatically oriented itself from the commands of the on-board computer. Borman merely "backed up" the automation, and was ready to take control at any moment.

Having flown over Siberia and Southeast Asia at an angle of 118 degrees to the equator, the ship entered the atmosphere. Radio contact was broken. The air around the capsule began to glow. The artificial "meteorite" could clearly be seen to the north of New Guinea. The heat screen was heated to 3000 degrees.

During the descent, at an altitude of 55 km, the capsule under the effect of aerodynamic force "skidded" in the atmosphere, and then again sank into it. The capsule landed safely in the Pacific Ocean.

While a flight to the moon lasts just several days, an interplanetary flight, as has already been said, will take long months and years. During the flight, the spacecraft will leave the sphere of terrestrial gravity, it will pass through a section of the route in the field of gravity of the sun, and will enter the sphere of the destination planet. Here, during the flight, the ship will be disturbed by the solar wind and other space factors which deflect it from the calculated path.

For determining the coordinates and calculating the flight trajectory, on the interplanetary ship the navigator-engineer will have available optical, radiometric and other systems as well as on-board calculators. Here, the cosmonauts will experience psychological difficulties and special training will be needed to surmount them. This can be appreciated in comparing orbital flights with interplanetary ones.

With orbital flights, as in airplane flights, the cosmonauts can observe the earth's surface directly through the windows or optical systems. They can determine their location by "scanning" the earth and from the location of ground objects. With the use of a "Globus" instrument or a map, the cosmonaut projects his position on one or another area of the earth's surface. To put it briefly, in the process of an orbital flight, the cosmonaut is always be able to trace the trajectory of his flight by "latching onto" specific ground markers. For example, he may reason as follows: "Ten minutes ago I was over North Africa, now I am over the Black Sea, and in 10 minutes I will be over the region of the Ural Mountains."

Thus, we see that, in making an orbital flight and using the instrument displays or carrying out direct observation, the cosmonauts construct a scheme of spatial orientation "in a terrestrial manner."

But the route of an interplanetary flight will not pass between relatively immobile points, as is the case in an orbital flight, but rather between two celestial bodies which are at astronomic distances and moving at a cosmic velocity in their orbits.

In an interplanetary flight, the cosmonauts will see an unusual picture of the heavens which encompasses the lights of the entire celestial sphere and not just the northern or southern hemisphere. Determining location will be achieved by using optical instruments in measuring the angles of "reference" stars in a completely different, unusual system of coordinates. This location is expressed in a certain "abstract" point which is not directly correlated to any specific mark. As well the calculated point which the ship should reach at a designated time is also devoid of visibility, since the flight trajectory will be calculated with a lag. The planet which is to be the aim of the journey at the moment of the calculation will be at a completely different point.

After the flights of the American astronauts on the Skylab orbital station, statements were made by individual scientists that with long flights it was not essential to create artificial gravity. However, we feel that artificial gravity should be created without fail, and for this the ship will be "spun" at a definite rate relative to the center of mass. It will also be oriented in a definite manner in relation to the sun and other planets. For stabilization and "spin" of the ship, it has been proposed that a very complex system be employed, including sensitive sensors (optical, gyroscopic and so forth), the signals from which after conversion in the logic blocks will be sent to the activator organs in the form of small jet engines operating on compressed air or liquid fuel. This will require from the navigator-engineer a detailed knowledge of these systems and the ability to operate them.

On the Vostok, Mercury, Soyuz and Apollo spacecraft, there were several receivers and transmitters making it possible to transmit teleinformation on the work of the ship's systems and the state of the physiological functions of the organism of the cosmonauts, to provide two-way radiocommunications under telegraph and telephone conditions, as well as provide TV transmission to the earth. In these flights, the crew commander was, as a rule, responsible for communications.

The functions of communications on an interplanetary ship obviously will be incomparably more complex. Aside from the transmitters, receivers and television equipment, there will be locators for navigation needs as well as for promptly detecting meteorites and asteroids.

Obviously, laser equipment can also be used for providing communications in the interplanetary flights.

Aside from receiving and transmitting "business" information, radiocommunications in an interplanetary flight should play one of the important roles in preventing neuropsychic stress caused by "sensory and information starvation." With two-way radiocommunication and television, the cosmonauts will be able to constantly keep track of life on earth, "to attend" theaters, the movies and stadiums, to see their close ones and friends, and talk with them. And how precious and desired this thread in interplanetary life will be can be seen even from the diary entry of the backup of V. V. Tereshkova who was being tested for neuropsychic stability in an isolation chamber. Here is what she wrote in her diary: "I thought how precious for the space pilot will be that delicate thread linking him with the earth, radio! How he will intensely listen to the wavering sounds, and with what sadness he will think that the others have earth under their feet, and that they together, can be threatened by nothing! And I.... If I, still sitting on the earth feel this, then out there all of this would be millions of times stronger" [40, p 26].

That radio contact in a long flight will be of enormous significance in combating such emotional tension is also substantiated by the observations of polar explorers. For example, here is how radio equipment was viewed by the French researcher /Mario Mare/ who spent a winter in Antarctica in 1952-1953. In his book "Seven Among the Penguins," he writes: "Our radio shack was the most precious thing we had. For it was due to radio that we could maintain constant contact with the outside world, talk with our near ones, and escape from the heavy burden of solitude" [148, p 59]. In another place: "We were able to send radiograms to our dear ones and friends.... We were supported by their approving sincere words. If we would not have had this constant contact, our life would have been heavier and the mood would have deteriorated" [ibid., p 89].

Here is how the effect of radiocommunications on mental states is described by the American physician and balloonist Simons who in 1957 ascended on a balloon to an altitude of 30 km: "During the nighttime hours, the delicate thread of radiocommunications with my friends suddenly became very important for me. While previously I was irritated by the fact that they impeded my observations with their unceasing questions and demands, now I was overjoyed at every opportunity to speak with them" [171, p 128].

The listed tasks and the complicating of radio equipment will make it necessary to introduce the position of a widely specialized radio engineer in the crew of the interplanetary ship. This is also substantiated by the great experience of various expeditions and the crews of seagoing vessels and airliners the personnel of which includes radio operators without fail.

On interplanetary ships, in the opinion of a majority of researchers, an ecologically self-contained life-support system will be operated. The earth, in essence, is an enormous spacecraft traveling in the expanses of the universe, and on which there occurs an ecologically self-contained

Figure 1. Space Radiocommunications With Soyuz-9

process of restoring all the substances necessary for the existence of living organisms. The possibility of utilizing this process for the needs of cosmonautics, this "prompting" of nature was seen for the first time by K. E. Tsiolkovskiy. In one of his articles in 1911, he wrote: "Just as the terrestrial atmosphere is purified by plants with the aid of the sun, so our artificial atmosphere can be renewed. As on the earth the plants with their leaves and roots absorb the offal and produce food in its place, so can plants taken by us during the journey work constantly. Just as every living thing on the earth lives by the same quantity of gas, liquids and solids and which never decreases or increases (not counting the falling of aeroliths), so we can live eternally by the stir of matter taken with us. Just as on the earth there is an infinite mechanical and chemical circulation of matter, so can it be carried out in our small world" [18, pp 73-74].

There are two ways for creating an ecologically self-contained system. The first way is by creating a complex or, more accurately, an entire chemical plant which will carry out the circulation of matter on a physicochemical basis. All its waste products will be broken down to water, the simplest acids, bases and mineral elements. Then the products necessary for human life support will be synthesized from them.

The second way is by creating the circulation of matter similar to what occurs on our planet.

At present it is still impossible to turn either the first or the second idea into reality. For this reason, we are convinced, on the first interplanetary ships, the circulation of matter will be provided both by individual biologically self-contained elements as well as by using physicochemical processes in special systems.

The first experiments conducted in scientific research laboratories have shown that the single-cell alga, Chlorella, can be used for completing circulation in terms of the gas composition. In the laboratories of one of the scientific research institutes in the USSR, in 1967, a compact automated complex was developed which used Chlorella for regenerating the air. Under the effect of the rays of a xeon [sic] light, in special containers which had just 500 grams of alga, photosynthesis was achieved. For 30 days, the Chlorella absorbed the carbon dioxide given off by one subject, and, in turn, produced oxygen which fully satisfied the need of the man. Here, the alga responded sensitively to the behavior of its "partner." For example, when the person slept, the rhythm of the metabolic processes of the Chlorella also slowed down.

Figure 2. Command Post From Which Radio Contact Was Maintained With the Salyut Orbital Station

Several years later, an experiment was conducted whereby three subjects for 6 months lived in a self-contained space where the oxygen and partially the water and food were replenished with the aid of plants.

In all probability, the biological method of the regeneration of air on an interplanetary ship will be carried out in combination with the chemical method.

At present the opinion has become established that the cosmonauts in an interplanetary flight will use water taken not from the earth but regenerated from the products of human vital activity, since the regeneration unit will be scores of times lighter than the amount of fluid necessary on the flight.

In a year-long sealed-chamber experiment conducted under terrestrial conditions, the urine secreted by the subjects was the source of obtaining water, as well as the condensate of liquid generated during respiration and lost with body evaporation (the so-called condensate of atmospheric moisture).

The regeneration of drinking water from the fluid given off by the organism was carried out by the oxidation-catalytic method in several stages: filtration of the urine, its evaporation, and high-temperature oxidation of the organic compounds to simple gases and oxides in the presence of catalysts. The condensate, after enrichment with the necessary salts and microelements, was successfully used as drinking water. Regeneration of water from the condensate of atmospheric moisture was achieved by the oxidation-sorption method using filtration, oxidation of organic compounds under the effect of an ultraviolet light source, with further purification in special ion-exchange resins. Obviously, the work of the regeneration unit on the interplanetary ship will be based on the same principle.

During the first interplanetary flight, a significant portion of the products will be brought in a dehydrated form from the orbiting cosmodromes, while another portion will be reproduced during the flight. The idea of K. E. Tsiolkovskiy of growing plants on board a spacecraft was embodied for the first time in the experiments of the Soviet scientist F. A. Tsander. "In 1926," he wrote, "I grew plants in a beaker with water that had been fertilized with waste products in a ratio of 1:200." In considering weightlessness, Tsander assumed that it would be necessary to move to other media from the growing of the plants in water. Later he wrote: "I have grown peas, cabbage and certain other vegetables in charcoal which is 3-4 fold lighter than ordinary soil. The experiments showed that it is possible to use charcoal which had been fertilized with the corresponding waste products..., all the wastes can be converted into usable fertilizers in 24 hours. In such a hothouse filled with pure oxygen, with carbon dioxide at the high temperatures which can be obtained in interplanetary space, it is possible to expect very large harvests" [22, p 114].

In the hothouses of a spacecraft, in all probability, such vegetables will be raised as cucumbers, peas, tomatoes and beans, and of the root crops, carrots, rutabaga and turnips. Obviously, potatoes will also be raised.

On an "industrial scale," such a hothouse began to function for the first time in the USSR in a year-long sealed-chamber experiment. The hothouse was set up for continuous production with a 14-day ("lunar") growing cycle. Here is what a participant of the experiment, the biologist A. Bozhko, had to say about the work of this hothouse: "In our hothouse, rapid-maturing annual vegetable crops are grown such as field kale, cress, borage, and dill as they contain many vitamins such as A, B_1, B_2 and PP. In truth, the borage has fewer vitamins than the other plants, but on the other hand, it has the pleasant odor and taste of fresh cucumber.

"The day in our hothouse lasts 14 terrestrial days. Then night begins which lasts the same length of time. Such an alternation of night and day was not chosen accidentally as we cultivated the plants in terms of lunar days. In order that the plants were able to accumulate a biomass during the 'day,' the sowing was made 'at night,' as germinating seed does not require light. When our 'sun' comes out, the plants greet it with already developed leaflets.

"In order to have fresh greens always ready for the table, the sowing of the seed and the harvesting of the crop occur periodically on the 'assembly line,' so that we constantly have plants of different ages. Only such an assembly-line method of raising a crop is possible on a spaceship or planetary station as the plants can evenly and constantly accumulate oxygen in the enclosed space, give off carbon dioxide and reproduce food and water for the crew.

"The planted area of our 'space' garden was small, some 7.5 square meters. This is quite sufficient for three persons" [18, p 69].

Of great interest was the experiment of growing higher plants under the conditions of weightlessness on board the Salyut orbital station. The force of gravity is of great importance both for animals as well as for the higher plants, and in particular, the direction of their growth depends upon the gravitational vector. In this regard, doubts have been voiced that under the conditions of weightlessness the higher plants will be able to develop at all. The strategy of the work in the area of developing artificial ecological systems for interplanetary ships depends to an essential degree upon the answer to this question.

For the Salyut station, a unit was developed which provided an opportunity to grow the higher plants under the conditions of weightlessness using the hydroponics method. The unit was a cultivator which included artificial light sources, a tank with water and wicks saturated with a saline mixture and placed in containers made of thin rubber. On one end of each wick facing the light source, a seed was placed. With the aid of a small pump which was operated manually, each day a certain quantity of water was put in the rubber containers. The water, in rising up the wick and in dissolving the salts contained in it, became the nutrient solution for the plants. The cultivator contained the seeds of three crops: flax, "hibin" ["khibinskaya"] cabbage and Crepis.

During the first day on the station, the cosmonauts turned on the illumination of the cultivator and a movie camera for slow filming of the plants, and also supplied the first batch of water. During the entire stay on the station, they carefully carried out the "feeding" and visual observation, and photographed the studied plants.

Here is what G. T. Dobrovol'skiy related on 22 June 1971 during a TV report on the carrying out of this experiment: "I will now show you the compartment, the special compartment, in which our favorites are located.... This container has been called 'oasis'.... In this container are nine growing bags in which the seeds of various plants were brought here, to the orbit of the artificial earth satellite.... Here are the sprouts of these plants. You probably can see them now. The first sprout appeared 2 days after we put this container in working condition. The second to appear was this sprout here which has already caught up with the first, and it already has four small leaflets. Can you see? After this sprouts appeared in bags No 2 and 1" [183, pp 115, 117].

It may be assumed that animals as well, both lower and higher, will also be on board an interplanetary ship. Of the higher animals, in all probability, chickens and rabbits will be the most suitable for long flights, as they multiply rapidly and require a relatively small amount of feed per kilogram of weight increase. Single-cell algae, the tops of higher plants, protozoa, as well as the waste products from them such as the eggshells, pulverized bones and so forth will be the food for them.

Here we have briefly told of the principle of work of a complex biological and engineering life-support complex on an interplanetary ship. From the given description, it may be concluded that on such a ship, the need will arise for a chemical engineer who would be concerned with the technical questions of providing for the life-support means, in addition to a biologist. One of the functions of the biologist will be constant control over maintaining the biological equilibrium between people, plants and animals.

As is known, during the first spaceflights, there was no physician on board. However, during all the stages of a flight, physicians have constantly watched the physiological and mental state of the cosmonauts. They have been invisibly present in the cabin of the spacecraft, and monitored the most important functions of the cosmonaut's organism. This was done by using radiotelemetry. Pulse rate, frequency of respiration, and the biopotentials of the cosmonaut's heart and brain were transmitted to the earth. With the aid of television, it was possible to monitor their activities. In the event that any illness should occur, the ship could land on earth in a short interval of time.

A completely different picture would exist in an interplanetary flight. The ship will be millions of kilometers away from the earth. For this reason the crew must include a physician without fail. In terms of training specialty, the physician of an interplanetary ship will be like a submarine physician, since the living conditions on submarines are reminiscent of life on a spacecraft. Like spacecraft, submarines are equipped with regeneration units which absorb the carbon dioxide and generate oxygen. The submarine physicians, along with general medical training, study the illnesses which may arise in a person who has been subjected to the effect of increased air pressure, oxygen starvation, carbon dioxide poisoning, as well as study the effect of the microclimatic conditions of the self-contained space on the human organism.

The extended stay of people under different gravity conditions, isolation and unusual environment makes it essential that the physician be able to provide precise diagnosis, and spot insignificant functional changes in the organism which show growing overfatigue and other changes in the organism.

For diagnostic purposes, the physician will have available electrophysiological equipment and a biochemical laboratory. The basic purpose of medical supervision will be to detect occurring changes, the diagnosing and forecasting of their development, and, of course, the providing of medical aid. The carrying out of this mission will be possible only in providing periodic examinations and research using electrophysiological equipment, stress tests, as well as biochemical research on the inner environment of the organism. Understandably, the solving of problems in the area of determining various shifts in the systems of the organism and the forecasting of the dynamics of these processes would be impossible without a special on-board computer and other electronic equipment.

Computers are already being widely used in the area of biology and medicine, both in our nation and abroad. They "monitor" the patients, in analyzing their condition from numerous and, particularly important, rapidly changing parameters in various combinations. For example, the computer compares the pulse of the patient, the frequency of his respiration, blood pressure, gas composition in the blood, and the secretion of urine with the conditional "standard patient," and not only displays exhaustive data on the state of the person being monitored on the physician's board, but also forecasts the course of all the processes in the future, thereby indicating to the physician to what special attention must be paid.

On the interplanetary ship, the diagnosing and forecasting machines will be even more advanced. This will also have an impact on the training of the cosmonaut physician.

As the research indicates, neuropsychic illnesses frequently arise in persons who are for a long time under conditions of isolation and work under extremal conditions. These ailments most often are of a functional character, and are manifested in the form of neuroses and reactive psychoses. From this circumstance stems the need to provide good training for the ship's physician in the area of psychoneurology.

The development of neurotic states can be caused by mental stress which arises in the relationships of people in group isolation. This circumstance will necessitate profound knowledge on the part of the physician in the area of social psychology. This will make it possible to promptly prevent the arising conflicts. Judging from the book "Na 'Ra' Cherez Atlantiku" (Across the Atlantic on the 'Ra'), its author, the physician Yu. A. Senkevich, was well trained in the area of social psychology. Obviously this can explain the profound analysis given by him of the dynamics of the relationships among the crew members.

The cosmonaut physician should be able to provide emergency surgical aid during the flight.

The physician, like the other crew members, along with performing his basic functions, must also master several related professions. The standing of watch at the command post of the interplanetary ship can be put among one such job. This requires from the crew members general knowledge in the area of navigation, power systems, chemistry, biology, and so forth. Here each of them will act also in the role of a researcher both during the flight and on the planet to be studied.

In any collective, as a rule, the need appears for coordinated actions, about which Karl Marx wrote: "Any directly social or joint labor...requires to a greater or lesser degree control which establishes the coordination between the individual jobs and performs the general functions arising from the movement of the entire production organism in contrast to the movement of its independent organs. The individual violinist controls himself, while an orchestra needs a conductor."[1]

Control over people is considered one of the most complicated and difficult types of activity. It will hold a special place in organizing group activities and in the dynamics of interpersonal relationships of the small collective which is forced to spend an extended time in hermetically enclosed quarters of the ship. Not only the smooth coordinated work of controlling the ship but also the emotional climate in the collective will depend greatly upon the activities of the commander.

Regardless of the fact that there are other opinions, we feel that the crew commander will be a professional cosmonaut pilot having not only flight but also well-rounded engineering education. Before becoming the commander of an interplanetary ship, he will make several spaceflights over "near" orbits, and work on an orbital station. Practical work in near space as well as continuous improving and broadening of this knowledge will allow him to have a good understanding of space navigation, radiocommunications, the design and functioning of the basic systems of the ship as well as many other questions of cosmonautics.

Of our contemporaries, one such cosmonaut is V. A. Shatalov for whom not only high professional preparedness is characteristic, but also the ability to instantly assess the situation and take decisions. This is particularly valuable for a cosmonaut.

The role of authority is particularly great in organizational activity. As is known, the word "authority" in its first meaning is translated from the Greek as "power" or "influence"; in the second, as a person who has influence or general recognition. In his article "On Authority," F. Engels has written that with the use of machinery in industry, transport and agriculture, combined activities become more complex, and these are impossible without authority. "But," F. Engels has written, "the necessity of authority (and the strongest authority) is never more apparent than on a ship in the open sea. There, in a moment of danger, the life of everyone depends upon the immediate and unfailing subordination of all to the will of one."[2]

1. K. Marx, "Capital," Vol 1. K. Marx and F. Engels, "Works," Vol 23, p 342.
2. F. Engels, "On Authority." K. Marx and F. Engels, "Works," Vol 18, p 304.

In group activities, subordination is a necessary condition for the better execution of the tasks in the interests of the entire collective or society. But, nevertheless, a feeling of subordination is sometimes perceived as enforced and externally imposed. For this reason, in joint activities, it is important not only that the crew members understand the necessity of subordination, but also observe the second meaning of the word "authority," that is, the commander should actually be a person who has general recognition.

In speaking about the qualities of the leaders of the Antarctic expeditions, V. V. Boriskin and S. B. Slevich have noted: "Each labor collective, particularly a polar one, should be based upon strict discipline. The forms and methods of establishing it can vary, but the greatest effect, as practice has shown, is achieved by discipline based on awareness, on mutual respect, and on confidence and respect for the leader" [21, p 37].

The living conditions of the collective under the conditions of a spaceflight place particular demands upon the selection of the leader. The crew members should be confident that the commander will not make the slightest error, or become confused in difficult circumstances. He must know the people well, and be able to win their confidence.

The psychological significance of the commander's authority is enormous. Confidence in the correctness of his actions during critical moments frees the people from such torturous wonderings as "Did he take the correct decision?" "Has a mistake been made which will entail fatal consequences?" With a firm conviction of the correctness of the commander's actions, all the efforts of a person are aimed at the creative fulfillment of the order given him, and not at such doubts.

R. Amundsen can serve as an example of such authority. Once after conquering the South Pole, at a reception he was asked: "How did you, captain, view punishment for the nonfulfillment of an order during the race to the pole?" Amundsen answered: "I do not know these words, and I cannot imagine what they mean. I chose a type of person that I would never have to think about this.... We were united by a common cause and my every wish was an order for them." Then he was asked the question: "And if you asked one of them to jump in an abyss?" "He certainly would have broken into laughter, having taken this as a stupid joke," replied Amundsen. And a little later he added: "But incidentally, it is possible that he would have jumped. He would have figured that this was essential. These people trusted me totally" [216, p 184].

Dr Sverdrup who spent 3 years on the vessel "Maude" under arctic conditions has written: "In being on board the 'Maude,' I was able to get to know Amundsen excellently, and not as he appeared during formal receptions, but as he was in actuality.

"...He was decisively interested in everything, he wished to analyze and study everything. For example, for hours he would question me about the problems of biology. He willingly spent his evenings in our company. It was very interesting to listen to him, and he could go on telling stories infinitely. He was able to interest each of the members of our expedition in some matter and excite them. Moreover, he had remarkable abilities, or to put it simply, talent. He could have been a magnificent teacher, and the students would have carried him on their shoulders. If someone was successful in his work, he was never short on praise, quite rightly feeling that nothing provides such an impetus to continue what has been started as commendation. We had a profound affection for our leader, we obeyed him willingly and made every effort to never disappoint our captain in any way.

"These talents of Amundsen were all the more valuable in the fact that in being in uninhabited areas and as before without a radio, we were completely cut off from the world. He was concerned with cleanliness not only in the literal sense. On the 'Maude' never a word or expression was heard which could not have been repeated Sunday morning in leaving the church. And no matter what happened, on the vessel friendship and a happy mood always reigned. During the several winters on the 'Maude,' I was able to become better acquainted also with the comrades of Roald Amundsen from his preceding expeditions. To a man they all stressed that with him they felt safe. He had an ability inherent only to him to foresee difficulties and obstacles which were unexpected for everyone, and then to courageously surmount them. He never tempted fate, and never attempted to solve problems unfamiliar to him without thorough preparation. For this reason, his comrades in the expedition esteemed him, and were ready to follow him into Hell itself. They knew that he had profound paternal feelings for them, and they returned the same to him. They never criticized him and never demanded anything from him" [216, pp 220-221].

In the absence of authority in relations between the commander and subordinates, emotional stress can arise which in certain instances may grow into a conflict. The leadership of small expeditions occurs under specific conditions. Here the commander in relationships with his subordinates is not only in professional, service (formal) contact, but also in an emotional human contact at a close "distance." The latter circumstance often leads to a situation where the leader begins to lessen the exactingness upon his subordinates, he loses the functions of a leader and permits excessive familiarity.

For maintaining this "distance," since antiquity definite forms of relationships between superiors and subordinates have been worked out empirically. They come down, in the first place, to observing the formal (regulation) forms of contacts, and, secondly, to separating the command personnel from joint living with subordinates (different cabins and different quarters for eating). However, under expeditionary conditions it is not possible to observe these conditions of relations. There, as Boriskin and Slevich write, where "the discipline established in the navy has been transposed without a special change in the forms and methods, in the American Antarctic expeditions, antagonism is often observed between the chief of the station and the remaining collective" [21, p 37]. Experience shows that the most favorable emotional climate is established in those collectives where the chief, in possessing great tact, uses a democratic style of control, but does not resort to excessive familiarity.

Here is how Yu. A. Senkevich explains the success of Thor Heyerdahl, the commander, under expeditionary conditions. "His authority is not hollow, and, equally important, he does not regale himself in this authority. He could be slapped on the back (in truth, I did not try it), he stood watch just like everyone else, and helped with the heavy beam without being asked. In essence, for a larger portion of the time he was not a captain, but rather a sailor, a rough deckhand, like any of us, as the circumstances necessitated this, the crew was small, and the combining of duties was indispensable. But I have known people who in similar circumstances would quickly have become 'buddies' who had lost the desire and the right to command.

"Thor, I repeat, was different. His democracy was not unprincipled. The transition from Heyerdahl the sailor to Heyerdahl the captain was made naturally, soundly and always with good purpose" [185, p 98].

The absence of various abilities as well as the characterological features of a personality can tell unfavorably on relationships under expeditionary conditions. This is eloquently seen from the work of I. K. Keleynikov [83, 84] who conducted medical and psychological studies on 13 collectives of hydrometeorological stations which were working in the Far North. He established several collectives where the superiors were in a sharply expressed conflict with the coworkers.

Academician V. V. Parin has written that on one scientific polar station "the 'regular' chief had lost control over the collective. He had replaced reasonable will with shouting, he did not understand the people, he was not able to hear them out, and hence utilize their strong points and their collective reason for the good of the matter. All these qualities of a true leader were possessed by another member of the expedition, and they were apparent. Several difficult months and the work, previously compulsory, was finally fulfilled. The responsible decisions began to be made by that man who was capable of this" [172, p 396].

In essence a similar situation developed during the winter on the expeditionary vessel "Belgica" in the Arctic under the command of de Gerlache. "De Gerlache," wrote A. and Ch. Tsentkevich, "lost interest in everything, and shut himself up in his cabin. He more and more often fell into protracted forgetfulness and could not, and possibly, did not want to come out of this state. Fate had dealt severely with him. Instead of reaping the glory of a polar explorer in the salons of Antwerp and Brussels, he was sitting trapped here, in the polar night, at the very ends of the earth. He was irritated by his own powerlessness, and the apathy of the crew was driving him wild" [216, p 62].

Evidently, the chief of the "Italia" expedition, Adm U. Nobile, lacked organizational capabilities as in a critical situation he was unable to prevent a split in the "Red Tent" camp.

At present, psychological methods are being worked out which help to disclose the qualities of an individual and predict the abilities of a person to command other persons. Upon appointment to the position of commander, it is essential, probably, to consider not only the results of the psychological research, but also all the preceding activity of the candidate for this position, including his services in conquering space, his authority, the ability to work with people, behavior in critical situations, as well as a number of other qualities disclosed in preceding flights in near space.

Thus, it may be concluded that the crew of the first interplanetary ship will include a commander, navigator-engineer, on-board engineer, radio engineer, chemist, biologist and physician, a total of seven persons. In the opinion of G. Miller [153], the "magic seven" can be reduced or increased by two units. We feel that the crew of the first interplanetary ship can scarcely be reduced. An increase by two or three persons is quite possible. The same conclusion has been reached by K. P. Feoktistov who feels that "obviously at first it will not be possible to send more than 10 persons to Mars or Venus. And this means that each of them to a certain degree should be an encyclopedist, that is, have several well-mastered specialties" [206, p 43].

CHAPTER II: SOCIOPSYCHOLOGICAL ASPECTS OF AN INTERPLANETARY FLIGHT

Experimental observations show that as a result of the failure to satisfy the human need for contact with other people and the limi.ed information on the external world using mass information media (radio and the press), changes occur in psychic activity, often leading to the appearance of unusual psychic states and to the development of neuropsychic illnesses.

Seemingly, in comparison with a one-man spaceflight, during the flight of the collective crew of an interplanetary ship, many of the psychological and psychoneurological problems will be eliminated. However, in practice it turns out that the problem of teamwork and the relationships confronts such a crew which during the flight must jointly control the ship and remain for an extended time in group isolation.

The urgency of this task can be seen not only from the observations of the work of pilots and cosmonauts, but also small groups of people who are forced to remain in isolation for an extended time (scientific expeditions, polar winterings, and work at hydrometeorological stations in inaccessible regions of the arth), in addition to a number of special experiments.

At present, in the social psychology problem of interplanetary flight, one can note two aspects, the aspect of joint activity in controlling the ship and the aspect of joint habitation under the conditions of protracted group isolation. Both these aspects have a great deal in common as well as a number of specific features.

Particular Features of the Interaction of the Crew Members in Controlling the Ship

> Human factors engineering, at the same time, should not overlook the fact that it is concerned with man, a social being, the object of labor and social relations and the object of life in all its fulness.
>
> A. N. Leont'yev

In executing flights on spacecraft of the Vostok and Mercury types, the cosmonaut performs piloting, navigating, engineering, communications and other functions. As we have shown in the first chapter, on an interplanetary ship these functions will be distributed among the different crew members.

Narrow specialization and the dividing of piloting, navigational, technical and communications functions between the individual specialists, on the one hand, contribute to the better servicing of the equipment, and on the other, require an understanding on the part of all the crew members of the common aim, precise coordination of actions, mutual confidence, and the ability to complement the work of one another.

However, here a general correct understanding of the mission by all the crew members, high professional skills and habits of each individual man are not sufficient. There must be a degree of relationships and interaction between the commander (the leader) and the subordinates (the led) which in various types of group activity is termed "teamwork," "pulling together," "playing together," and so forth.

The Voskhod was the first spacecraft the crew of which included several specialists. After the flight of this ship, V. M. Komarov wrote: "The research program was designed for 24 hours, and the crew fulfilled it completely. The missions which we were given to carry out in this flight required the participation of all the crew members. It was impossible for one man to solve them alone, no matter how well-trained he was. This required, in turn, not only the same understanding of the research questions by all the crew members, but also excellent teamwork, the understanding of one another almost intuitively, and even interchangeability.

"Our crew in space was small, but it acted as a close-knit Soviet collective, proud in the awareness that we were performing our job in the aim of peaceful goals and for the good of all mankind. All the crew members creatively helped each other in carrying out the complex and interesting work planned by our flight's program.

"Of course, all of this did not come about immediately. Before settling in the cabin of the Voskhod spacecraft, its crew had a great deal of hard work to do, as well as much to learn and a great deal of training" [89, pp 27-28].

Usually the "teamwork," "pulling together" and "playing together" are achieved as a result of protracted joint activity. However, as observations from the practices of brigade and crew servicing of transport indicate, coordinated activities even with extended joint work are not always high. And in these instances, the crew often cannot handle the missions confronting it, and conflicts arise among its members. There are even instances when the uncoordinated actions of the members of such crews lead to various accidents and catastrophes.

For creating close-knit crews, attempts have been made to make them up considering the individual features of each member of the crew. However, experience has shown that even with good knowledge of the individual psychological features of each specialist, it is impossible to predict with complete certainty how this person will act in a group, what relationships will develop between its individual participants, or how the actions of this individual will be coordinated with the activities of the other members of the group. And this is understandable as the group is not an arithmetical total made up of components, but rather a complex organism in which definite patterns are at work. Certainly it is rather well known that a team made up of individually strong "star" athletes loses to a team which is weaker in membership but which has played more together.

Analogous examples can be given from aircraft crew practices.

Interesting in this regard are the observations made by the pilot trainer I. Vydrin. He relates how an experienced first-class navigator was transferred to a bomber crew. The crew was excellent and led also by an experienced first-class pilot. But unexpectedly for the regimental command, the bombing results of this crew worsened sharply. Moreover, there were instances of runs without bombing and the return of the bombs to the airfield. Seemingly it would be impossible to spot the cause of the failures in the crew's flight work. However, the monitoring of the tape recordings which recorded the radio conversation between the navigator and commander during the flight was of help. "In listening to the recordings," I. Vydrin writes, "from the very outset in the voice of the commander, you could feel irritation and nervousness: 'Navigator, course!...course...navigator!' and immediately followed the rebuke: 'What is holding you up?' And every second there were unnecessary clarifications and the demand for reports on the location of the aircraft even if only 'by sight.' On the other hand, the navigator was clearly becoming enraged and shouting over the aircraft intercom: 'Commander! I said turn half a degree and you turned a whole three!' and so forth. In listening to this and other recordings, you could involuntarily imagine their excited faces and nervous movements. The commander did not trust the navigator and constantly, without any particular need, pressed and inquired of the flight parameters. The navigator, in turn, took this hard" [35, p 42].

At first glance, it might seem that in such instances the absence of friendly contacts, insufficient respect for one another or even dislike lie at the basis of the uncoordinated activities. With a more profound analysis, it becomes clear that the reason for the separation and conflict consists in something else. It is the inability in critical situations to understand one another, the "lack of synchronization" in the psychomotor reactions, differences in attentiveness, thinking and so forth, in general, the congenital and acquired properties of the personality which impede joint activity.

Experienced educators usually promptly detect the factors which impede teamwork, and on the basis of empirical experience make reassignments, but this does not always lead to the expected results.

To the degree that knowledge of the individual features of individuals comprising the group as well as empirical experience have not provided the making up of psychologically compatible crews, an urgent need has arisen to study the psychological patterns operating in small groups in controlling aircraft. Thus, in particular, one of the U.S. bomber aviation formations during the period of the military actions in Korea suffered serious losses. In the same formation, in comparison with the others, there had been a large number of flight accidents often terminating in catastrophes. The Pentagon, concerned with these circumstances, sought help from a number of leading American psychologists. The psychological research conducted established a definite link between efficiency in carrying out group missions in an experiment with the combat losses and flight accidents. The crews were re-formed on the basis of the recommendations given by the psychologists, and after this the losses and emergencies declined sharply [29, p 207].

It must be pointed out that research in the area of studying the patterns operating in small groups was commenced in our nation by the well-known psychoneurologist V. M. Bekhterev. The results of his observations and research have been published in his book "Kollektivnaya Refleksologiya" (Collective Reflexology) in 1921.

The needs of developing cosmonautics have urgently posed the task of working out the procedures for staffing and training efficient crews. Certainly insufficient understanding among the commander and crew members of a spacecraft or an insignificant error on the part of one or another specialist in the interrelated activities of controlling the craft could lead to tragic consequences. All of this requires the disclosure of the psychological patterns operating in a group with the joint command of the spacecraft.

Before beginning to analyze these mechanisms, we should say that up to the present comparatively few spaceflights with a crew of several persons have been made. Naturally this circumstance has not made it possible to acquire extensive material on the basis of which general patterns could be deduced. For this reason, in the future we will use material from aviation practices and experimental group psychology. Of course, there are differences in the control of an aircraft and a spacecraft, and one such difference is the circumstance that while almost all the crew members (the pilot, navigator, engineer, radio operator and copilot) are involved in controlling the aircraft, in executing a maneuver of the interplanetary ship, this obviously is not required from the chemist, biologist and physician.

The flight conditions are also different. The physical patterns which must be considered in controlling an aircraft are of one sort (aerodynamics), and in controlling a spacecraft they are different (ballistics). However, from the standpoint of group psychology, these differences are not great.

In examining the activities of the crew members of an aircraft, it can be seen that the commander (he is also the pilot) maneuvers the ship on all sections of the flight. The navigator, in operating the navigation equipment, plots the route of the flight. The engineer from his control board regulates the running of the engines and the numerous aircraft systems. The radio operator, in handling the receivers and transmitters, maintains contact with the ground flight control stations. Each of them individually acts in the role of an operator at his own control panel.

Common to the labor of an operator controlling any machine is the fact that all the changes of the controlled object are picked up with the aid of sensors. The signals from the sensors are converted and transmitted to instruments which the man is watching. He perceives the instrument readings and in accord with the set program executes an action which can be either very simple (pressing a button) or more complex. The signal which arises as a result of the man's action is converted and is sent to the controlled object, changing its state. The new state of the machine is accompanied by changes in the instrument readings which inform the man of the results of his actions. This, in turn, may necessitate new actions by him, and so forth. This, generally speaking, is how the "man-machine" system looks and in which the operator who has direct links and feedback with the controlled object acts in the role of the "program carrier" for the work of the system and as a regulator. Here, the program is fulfilled in the process of the circulation of information between the operator and the controlled system.

However, the joint result of the work of the operators is formed not from the simple total of the contribution of each of the crew members to the general activity (the interaction of the individual contributions similar to "funneling"), but rather from joint interrelated activity (reminiscent of the principle of "interconnecting vessels") which provides for the stability ("homeostasis") of the controlled object as a whole. In controlling an aircraft, this appears as follows.

The actions of each specialist at his control board entail changes in the controlled object, and this is reflected in the instrument readings. Depending upon the set program leading the system to the target, these changes in the instrument readings cause immediately or after a certain time response actions by participants of the group. In other words, the actions of one person cause not only a change in the controlled object (machine), but also expedient reactions by the partners who consider this "disturbance."

Such interrelated activity is provided by establishing a hierarchy which is a system of subordinational functional relationships between the members of the group activity. These subordinational relationships are rationalized and are subordinate to the logic of the missions being carried out.

The functioning of the leader (commander) and the led (the specialists) occurs under the conditions of direct links and feedback provided by the intercom and the instruments. For example, the controlling actions of the commander based on all the information received from the navigator, engineer and radio operator determine his effect on the movement of the aircraft in space. The arising changes in the dynamics of the aircraft's movement are perceived, let us say, by the navigator from the instruments. These links make it possible for the commander, in controlling the ship, to correct the efforts of the entire group in that pace and rhythm which are "set" by the space-time dynamics of one or another maneuver under the specific conditions of the external situation.

From all that has been said, it is not difficult to conclude that the relationships of operators in joint work act not directly but indirectly through the communications channels and operating mechanisms. A sort of new system arises which in human factors engineering has been termed "man-machine-man."

In the aim of modeling the interrelated activities in the "man-machine-man" system, a collective of scientists headed by Prof F. D. Gorbov has formulated the following requirements.

1. Group activities should be simple so that the preliminary development of specific skills is not necessary; otherwise the subjects will not be under equal conditions.

2. The activity should be interrelated, that is, the model should provide cross ties between the operators and carried out with an obligatory sequence of working operations according to a preset program.

3. The evaluation by an operator who is a member of a group of the results of his work should be done indirectly, through the instruments.

4. The activity, its course and results should be objectified (that is, the recording of the process of solving the experimental problems should be provided).

In accord with these requirements, a so-called homeostatic method was created. The basis for developing this method was the study conducted by F. D. Gorbov of people using a shower in one of the medical institutions. In this shower there were four stalls, but the diameter of the pipe did not provide a sufficient amount of hot water for all the washers. When four people entered the stalls simultaneously, one could observe various actions of the persons washing undertaken for the purpose of creating conditions close to the optimal (comfortable). The attempt to achieve the best conditions by one person led to a response by the remaining showerers. They began to turn the faucets, and as a result the first was doused with either cold or extremely hot water. Only at the price of abandoning the egocentric tendencies was it possible to establish conditions acceptable for all, and this necessitated the "struggle" of various plans of action in a "game" situation. But if one person insisted on creating advantages for himself, then the entire system lost its stability due to the counteractions by the remaining showerers who were doused in cold water. As soon as this person left the shower room, the remaining persons quickly reestablished acceptable water supply conditions.

From this actual experiment, the conclusion was drawn that purposeful, interrelated activities during control are more effective the smaller the scope of oscillating processes (in the given instance, in terms of the water temperature parameters). Consequently, the effectiveness of interrelated group activity can be determined on the basis of whether or not a certain level of equilibrium is established in the system. Thus, an effective and active group which quickly establishes equilibrium in the system can be characterized as a stable group having homeostatic features of adaptation.

An experimental reproduction of the situation close to the "shower room" was carried out on a specially designed device which has been called a "homeostat." The homeostat consisted of three and more control panels (depending on the number of persons being tested). The task of each of the members of the studied group was to set the indicator on his panel at zero. During work, each subject, in receiving information from his own indicator, operated it and at the same time affected the indicators of the partners in the group. The experimenter from his control board could vary the degree of difficulty of the problems being solved. The task was considered executed only in the instance when all the subjects placed the indicator on the "zero" reading. Due to the recording of the movement of the handles and all the indicators on an oscillograph, it was possible to trace not only the character of action of the entire group as a whole, but also the tactics of each member of it. The recording of changes in brain biopotentials, the frequency of heart contractions, respiratory movements and the cutaneogalvanic reflex, in performing operator activities, made it possible to judge the emotional state of the subjects.

Thus, an experimental model was created for interrelated and interdependent control activities and during which the entire process of controlling the system as a whole was carried out indirectly. The only source of information for each operator was the indicator of his own instrument which was controlled not only by his own actions but also the actions of the other partners.

Experimental research has made it possible to establish that in solving simple problems, the strategy of the group remained on the simple levels of activity by the subjects, and this provided for the successful solving of the problem. However, in solving more difficult problems, this strategy no longer brought success if any of the operators altered his tactics. With a complicating of the problem, one of the operators was to abandon the "natural" tactics. Such an operator, conditionally called the leader, no longer endeavored to immediately put his indicator on zero, as he had done before, but either waited until it itself moved in the required direction under the effect of the working partners, or, as was inherent to the most active and effective subjects, disregarding the temporary loss, purposefully moved his arrow away from the zero, if this was the tendency of its spontaneous (but, certainly, related to the activity of the partners) movement. This operator, in acting at one minute seemingly against his own interests and then bringing the indicator to zero, gradually reduced the amplitude of the oscillating movement, thereby bringing the entire system into a state of equilibrium on the set level (that is, in the given experiments to zero).

The research of M. A. Novikov in modeling group activity [162, 163] has made it possible to understand rather fully the functions of a leader in a group not only as a more "quick-witted" member of the experimental group possessing such psychological qualities as self-control and the ability to evaluate a situation quickly and adequately, and able to act precisely and purposefully in the aim of coordinating the actions of the entire group as a whole, but also as a person capable of the very delicate regulation of the intragroup processes. These experiments also showed that complex group interdependent activity cannot be effectively performed by a group in which the necessary psychological structure for the given activity has not been formed, regulating the strict allocation of functional duties between the group members, that is, between the leader and the led.

In those instances when in the homeostatic experiments a struggle arose between two operators for taking the initiative of control into his own hands, more often the struggle was won by that subject who more carefully and adequately analyzed the incoming information, and more quickly generalized and forecast the possible actions of the partners. In certain instances, two leaders appeared who were equal in terms of their psychological capabilities. However, having assessed the situation, one of them quickly moved into the role of the led, having given up his egocentric drives for the sake of group success. As an illustration, we will examine an example from athletics.

Rower I. who rowed on the "Storm Petrel" team and who had shown himself to be the leader of this group was sent to the eight-man shell of another team for strengthening it. The observations of the coach and the experimental research showed that I. in the other group behaved as a pure follower, and did not even think of his former tactics as a leader. When, after the homeostatic experiment, he was asked why he behaved differently than on his own team, he replied that his new place (number two man) obliged him to do this as "I am no longer the stroke oar!" [164, p 118]. In this fact, as in many similar to it, we encounter instances of the conscious abandoning of initiative for the sake of another member of the group for successfully solving the common problem.

These observations again strongly stress the erroneousness of the opinion that the leader is the best member of the group, while the led are the secondary members. Both the leader and the led are like positions in an orchestra where there are both a conductor and musicians. Moreover, there are no good leaders with bad followers, since the group is a complex system and these "positions" are merely necessary with joint activity.

Leadership in operator activity, in comparison with leadership in significantly larger collectives, has its specific features. These specific features consist in the fact that the leader, being the official (formal) leader of the group, at the same time is also an operator. As a formal leader, he sets the tasks for the remaining operators, and during work he takes responsible positions upon which the fate of the system depends. As an operator, he acts as an equal member of the group who participates in the joint activity. Moreover, in the interests of the common cause, in certain periods of operator activity, he may have to concede, as an operator, the functions of the leader to another crew member. "In aviation," writes M. L. Gallay, "it often happens that the copilot who is a member of the crew has mastered one or another piloting element better than the first pilot, the crew commander" [42, p 48]. Precisely this was the case in the crew under the command of V. P. Chkalov during the nonstop flight from Moscow across the North Pole to America in 1937. In this crew, the duties of the copilot were performed by G. F. Baydukov who was one of the best masters of "blind" flying. The flight was carried out for a larger portion of the entire time in solid cloudiness, and the aircraft had to be flown blind, by the instruments, without seeing either the land or the horizon. In such cases, Chkalov turned over the control of the aircraft to Baydukov, that is, in remaining the commander of the ship, as an operator on his own initiative, assumed the role of the led.

In granting initiative within broad limits to the partners, the commander continues to carry out command functions. If one of the followers begins to violate the limits of the initiative granted him and insists upon the extending of them in spite of the resistance of the leader, then a struggle arises for initiative, and this may end in a conflict.

In one of the crews which consisted of two fliers, the commander was slower and had somewhat "lagging" responses in taking decisions and in acting, while his copilot was a quicker and more decisive person. In an emergency, a conflict situation arose over the interference by the junior in command and by his attempt to impose his line of behavior [52].

An analogous pattern was disclosed in conducting experiments on a homeostat by M. A. Novikov. He writes that there are particularly frequent instances of a temporary exchange of functions when the group got into a blind alley and could not solve the complex problem in any manner. In these instances, certain leaders consciously gave up the initiative to an energetically acting follower.

The most indicative in this regard were the experiments with the four-man rowing crews from the "Spartacus" (E, stroke oar) and "Zhel'giris" (Y, stroke oar) teams. A particular feature of the four-man crew of E was that one of the rowers (K) differed somewhat in style from the team, and did not always support the unanimous opinion of the group or the opinion of the stroke oar. The opinions between the group and K, and particularly between him and the stroke oar, were very tense, and sometimes developed into conflicts. Nevertheless, with the unsuccessful attempts to solve one or another homeostatic problem, leader E, in seeing the desire of K to assume the initiative, conceded it, in carefully monitoring the course of the experimental activities. Approximately the same was done by Y, and this helped his group to solve extremely complex homeostatic problems. Novikov who conducted this research pointed out that precisely these collectives competed most successfully in international meets and repeatedly won the title of European champions [164].

During group control of a machine, the commander is more reminiscent of the captain of a sports team and he himself participates in the game. In the team types of sports, the leader is either the one who "takes over" the game by energetic actions, or skillfully directs the actions of his partners, imposing his will on them and determining the line of behavior for the entire group.

However, it must be said that competition between two claimants to leadership in experiments did not always end so peaceably as in certain instances conflicts arose. More often the conflict situation arose as a result of the fact that one of the subjects, having taken over the role of the leader, carried out all his actions on a level of rough command, without performing those delicate control actions in dealing with subordinates which characterize a true leader. With the relatively passive actions on the part of the remaining operators, such a leader in solving difficult problems by his conduct evidenced regret and irritation with the appropriate verbal responses.

It must be pointed out that neurotic responses arose not only in the leader, but also among his partners in the experiment as a consequence of shouting and impolite dealing. This was substantiated not only by behavior responses but also by autonomic ones. As an illustration, we will give the observation of M. A. Novikov. Subject A was claiming the role of leader in a group. However, this level of the individual's pretension was not supported by the choice of the leader's tactics. He constantly adhered to primitive, inflexible tactics. In his behavior he was intolerant of others. Regardless of the prohibition of the instructions to talk with his partners, he gave instructions, he criticized them, he was nervous, he shook his head in annoyance, and sometimes abruptly and maliciously turned the handle of the controls to the right or left, causing the illogical disturbance of the indicators which threw his partners off [163].

We have encountered analogous situations in the actual work of aircraft crews. Thus, O. P. Yeritsyan [67] in his research has shown that in a majority of the "broken in" crews which he studied, the commanders possessed well-expressed leadership qualities. Their status as leader in the group is determined not only by their official position but also by the inofficial one. In conducting sociometric research, he discovered several crews in which the commander did not occupy a leading position in the informal structure of relationships. The teamwork of these crews was low.

One of the conditions for successful activity is the mutual confidence among the crew members. Here is how M. L. Gallay has described the appearance of this feeling in moving from a single-seater to a multiseat bomber. "In the cockpit of the TB-3 there were two enormous round control wheels and two pairs of petals.... On the other hand, there were comparatively few instruments on the panel, as almost all the equipment relating to the power unit had been moved to the separate panel of the flight mechanic. All the same, the pilot's attention could scarcely encompass such a large system. Such a freeing of the pilot from even a small portion of the diverse tasks imposed on him immediately seemed exceptionally convenient to me, but, as I learned subsequently, under one essential condition, that is, that a man who has the unlimited confidence of the pilot is seated behind the controls of the flight mechanic.

"Subsequently this was repeatedly affirmed in joint work with such excellent flight mechanics and engineers as A. P. Bespalov and G. A. Nefedov. But, on the other hand, in flying with certain other mechanics who did not inspire such confidence, I literally wanted to turn inside out in order at least to glance at the instruments on their board and see for myself that everything was all right" [42, p 35].

A feeling of confidence, as a rule, is based upon the reciprocal knowledge of the crew members of one another not only in operator activities but also in ordinary life. The fact of unofficial contact is characterized by an interest in the personality of a comrade, while the knowledge of one another can be expressed in sincerity and a feeling of responsibility for the success of the activity being executed. The teamwork of the collective as a single whole will depend greatly upon how the informal relationships are shaped.

The teamwork of the crew is manifested particularly clearly in difficult conditions and in emergencies. Precisely here all the crew members should be on guard and merge into a single whole. "From my own experience there are scores of examples," writes the instructor pilot, Hero of Socialist Labor G. I. Kalashnik, "when the absence of extra caution, reciprocal control and a feeling of solidarity in a crew entailed severe flight accidents" [76, p 9].

One of the authors of the present book, A. A. Leonov, ended up in such a difficult situation during the flight on the Voskhod-2 spacecraft. During landing, one of the commands in the automatic system did not activate, and the ship had to be landed manually. Here the functions were distributed in the following manner: A. A. Leonov watched the space key points and the earth through the window and gave information on the spatial position of the ship to the commander. On the basis of this information and the instrument data, I. I. Belyayev lined up the ship for landing it on the earth.

The teamwork of a crew in an emergency and difficult situations in essence is analogous to the actions of players in well-trained football, hockey and other teams. Playing in these team types of sports has a probability character. Teamwork under these conditions is provided by the presence of well worked out relationships and an understanding of the "pattern" of a partner's playing. The well-known Brazilian soccer play , Pele, has described his "ideal" young forward on the All-Brazil Team, /Cutenier/, as a player "able to guess his (Pele's) movements on the soccer field." An understanding of the game by the partners most often is of an intuitive sort, and is based upon the working out of a probability forecasting in a game situation by each of them. Thus, the crew members in a complex or emergency situation through the instruments should not only quickly assess, "catch," and "read" the dynamics of the developing situation, but also be able to forecast the probable actions of the commander and, in using the sports term, "play to him."

Research using a homeostat has shown that the successful solving of experimental problems depends upon the ability of the group, as an integrated system, to learn. In certain stages of training a group, one frequently observes mental stress and even conflicts arise. Analogous situations occur in brigades of operators serving automated systems and in spacecraft crews. Under these conditions, both in an experiment and in actual life, mental stress often arises as a consequence of the fact that the person has not yet learned to "read" the actions of his partners and the course of the entire process as a whole through the indications of the instruments on his control panel. Such an operator cannot promptly make his contribution to the common cause. For this reason, for preventing conflict situations, basic attention must be focused on training (instructing) the specialists.

In conducting experiments and in practice, operators have been discovered who even after extensive training are unable to acquire the skills of working in group interrelated activities, as is shown from the following observation of M. A. Novikov. Three persons are working in a group. The problems on the homeostat are being solved with difficulty. D constantly complained of T: "You should be pulling planks and not handling a potentiometer." At the end of the work, D began to complain of R, and R began to be hostile to T. The conducted numerous experiments did not lead to an improvement in the work. In the process of training, all the subjects showed substantial deviations in the autonomic functions (electroencephalogram, electrocardiogram, cutaneogalvanic reflex and breathing), and as a result of the lack of coordination, hostile attitudes arose in their work [135].

It is essential to stress again that determining suitability for professional activity under the conditions of an interplanetary flight cannot be limited to the presently existing procedures of psychological selection which basically consider individual psychological characteristics. It should also include such procedural methods which would make it possible to predict the capability of an individual to learn in a group.

In some instances, an operator, having mastered his job in one crew, in being moved to another for a long time cannot adapt to the new "style of language" in the group. This miscomprehension can lead to tragic consequences. Thus, on an aircraft, a gesture by the commander moving his right hand up was the signal for the flight mechanic to "raise the landing wheels." Sometime later, this flight mechanic was assigned to another crew, and during takeoff, having mistakenly interpreted the involuntary movement of the new commander's hand, began to bring up the landing wheels before the aircraft had left the landing strip. The case which ended in a catastrophe has been given in the book of M. L. Gallay "Cherez Nevidimyye Bar'yery. Ispytano v Nebe" (Across Invisible Barriers. Tested in the Sky).

In other instances, a miscomprehension of the "language" can also lead to chronic psychotraumatization. For example, in the crew of an air transport which consisted of four men, in performing the most crucial and difficult operations (the dropping of parachutists during the night, and the landing of the aircraft in difficult weather conditions), the uncoordinated actions of the navigator and the captain led to mistakes in dropping the parachutists, to the inaccurate approach of the aircraft to the landing path, and so forth. Since rather frequent and stormy conflicts had occurred between the commander and the navigator, professional activities were carried out under nervous conditions. The work of the crew was not altered by either administrative actions or analysis. And although each of the crew members profoundly felt the overall failure, the results did not improve. As a consequence of extended professional psychotraumatization, the navigator developed neurosthenia which necessitated his temporary grounding, while the commander of the crew developed an ulcer. After recuperation, the navigator was assigned to the crew of a highly skilled pilot, while a different navigator who had flown with many pilots was assigned to the crew of the former commander. In the new crews, both successfully continued their flight activity.

From the standpoint of psychological compatibility, a pilot who has flown with various navigators and a navigator who has worked in different crews possess a broad capacity to understand not only the intentions but also the mood of their partners. This ability as well as the ability to adapt to various individuals and to lead men provide the necessary teamwork in solving joint problems.

The problem of the efficient functioning of an interrelated group in controlling an aircraft cannot be solved in isolation from studying the interaction of the emotional states of the crew in the process of this activity. Instances of neurotic breaks and, as a consequence of this, a decline in the efficiency of general work have caused a number of researchers to seek out ways for resolving conflict situations.

For the purposes of studying conflict situations, in work on a homeostat, A. F. Bystritskaya and M. A. Novikov [25] employ a special procedure. In the first stage of the experiment, the group was trained, and the work skills were developed. Participating in the experiment were 27 groups of subjects with two-three and more persons in each group. In the second stage of the experiment, during operator activity when the work was approaching the goal, that is, an equilibrium state, the experimenter from his control panel introduced mismatched "interference." This procedure is based, in essence, on the notion discovered by P. K. Anokhin [8] that a discrepancy between the expected result ("the acceptor of the action") and its actual embodiment can be the prerequisite for the occurrence of a conflict.

The obtained results convincingly showed that the introduction of chaotic "interference" with the approach of the system to a stable state caused emotional stress which was expressed in a disruption of the previously elaborated, dynamic stereotype, up to the point of the loss of the skill and the inability to further solve the problem. In addition, the autonomic background and the behavior responses altered.

Then all the subjects who had shown neurotic responses were divided into two groups. The first of them which was the larger share was characterized by a predominance of behavior responses expressed in emotional and verbal disinhibition. Thus, engineer V, without having understood the essence of the chaotic "interference," transferred his irritation to the instrument and to his partners in the experiment. He irritably shouted that the instrument had been incorrectly designed, that the partners were slow, and so forth.

Bystritskaya and Novikov termed such a type of behavior response to a conflict as "local," in contrast to the "diffuse," where there is no choice of an object for releasing emotional tension and the subjects merely abandon further experimentation. Subject P in those instances when the instrument indicator, in moving slowly in the required direction, suddenly and quickly moved away from zero, was noisily indignant and stopped work, saying: "I do not know what to do," "I won't turn it anymore, it doesn't stop," and so forth.

Analogous data obtained in laboratory experiments have been transferred to real work conditions (aircraft crews, sports teams and other types of group activity). The results of the homeostatic experiments coincided with actual work, and this made it possible to conclude that the homeostatic method which models group activity reflects the true situation of relationships in real practical activity.

Quite naturally, the "theory of the small group question" was used in staffing the crews of the multiseat spacecraft. It goes without saying that the question was not limited to experimental psychological research. Educationalists, psychologist physicians and coaches studied psychological compatibility during training sessions on a training spacecraft, as well as in the process of sports exercises and rest. As an illustration it is possible to give the example of training certain crews of multiseat spacecraft, and, we feel it is best to start with the pioneer of of this class of ship, the Voskhod.

As is known, strong-willed persons trained for the flight of the Voskhod spacecraft, and each of these men possessed high professional qualities and an understanding of the entire fullness and responsibility of the mission entrusted to him.

During the first stage of training, both joint training for the crew as a whole as well as exercises of the individual crew men with a scientific coworker and physician were carried out. Such skills were worked on as maintaining radiocommunications, utilizing the life-support equipment, and so forth.

Then the cosmonauts trained on a Voskhod training spacecraft with the entire crew complement, mastering the actions which would be needed during the flight. The joint training sessions also provided an opportunity for each crew member to feel and assess the particular features of the activities of the remaining men, and to find the most acceptable and advisable method of his own activity. Particular attention was given to clear interaction in performing operations requiring the participation of all three crew members.

The comprehensive training conducted on a real time scale using the training spacecraft disclosed a teamwork, mutual understanding and interaction in the crew, and this made it possible to predict the successful fulfillment of the flight mission. Naturally, a high evaluation of the crew as a whole did not exclude individual psychological differences in each individual man.

The crew commander, V. M. Komarov, during the training manifested deliberateness and calmness. In preparing for each exercise, he endeavored to fully understand the mission. After carrying out the exercise, he made systematized, full, objective and self-critical reports.

A scientific coworker, K. P. Feoktistov, was characterized by enterprising and purposeful thinking in preparing each training session. During the training sessions, he demonstrated high awareness, and tenacity in a detailed examination of all the scientific observations being worked on by the crew. Characteristic to him was a creative execution of each training session and an original solution to certain, seemingly, already established and routine questions.

The physician B. B. Yegorov excelled in profound analysis of his own actions in the training sessions, in a broad understanding of the programed medical research, emotional calmness, steadfastness in overcoming difficulties in working out and reinforcing professional actions, as well as reasonable initiative.

Characteristic to the crew as a whole was a united understanding of the aim of the flight, an ability during a difficult moment to focus all forces on carrying out any task related to control of the spaceship and its systems, and on carrying out the scientific and medical research, as well as a readiness to subordinate their own particular tasks to carrying out the basic one. The flight of the Voskhod spaceship, as is known, was successfully carried out. The commander of the craft, Komarov, with his usual humility assessed his role as follows: "I should make clear that the commander of the ship is not the commander of a subunit. There was no one to command, or more accurately, this was not needed. We all knew our duties, and each of us performed them intelligently" [89, p 102].

Particular teamwork was demanded from the crew of the Voskhod-2 spacecraft. Only with complete mutual understanding, confidence and trust in one another could such an involved mission as a spacewalk be carried out. In assigning duties among the crew members, consideration was given not so much to professional training (both cosmonauts were highly skilled specialists), as to individual psychological features. Characteristic to P. I. Belyayev were will and self-control, calm behavior in dangerous situations, logical thinking with profound self-analysis, and great tenacity in surmounting difficulties.

Here is a small excerpt from a description of A. A. Leonov: "Strong, impetuous, he possesses an amazing ability to work under extreme conditions. Intrepidness, a synthetic way of thinking combined with the ability of an artist makes it possible for him to encompass and remember entire pictures and then reproduce them rather accurately." The two cosmonauts, different in character, in a way complemented one another, and this made it possible for this compatible group to successfully carry out the flight. An important feature of the training of the crew of the Voskhod-2 spacecraft was the fact that in comparison with the crew of Voskhod-1, the cosmonauts had to master a new process of locking under the conditions of a deep vacuum and unsupported space.

In the practice of spaceflights, coordinated activities are often required not only between the crew members of one ship, but also between cosmonauts working simultaneously on several crafts, and in particular, in the docking maneuvers of two spacecraft.

The docking of two spacecraft was carried out in the USSR for the first time in 1969. On the execution of this maneuver, V. A. Shatalov has related the following: "After the successful orbiting of the Soyuz-5 ship, the second stage of the flight commenced, that is, the orbital rendez-vous and docking. The Soyuz-4 and Soyuz-5 ships performed a series of maneuvers using manual control, and this brought about their further closing from a distance of more than 1,000 km. At a range of several kilometers, the automatic approach system was activated.... The automatic closing-in was monitored by me from the instruments and visually through the optical sight and the television unit. During the rendez-vous, the Soyuz-5 spacecraft was oriented with the rocking mechanism facing the Soyuz-4 craft.

"At a distance of 100 meters, Boris Volynov and I shifted over to manual control of the ships. In controlling the ships, we maintained their required reciprocal orientation. I changed the approach speed of the ships depending upon the distance between them. Off the coasts of Africa, at a distance of 7,000-8,000 km from the frontier of the USSR, we approached one another to a distance of around 40 meters and executed station-keeping. At this distance, Boris Volynov and I executed several maneuvers which altered the interpositioning of the ships, while photographing one another. We then continued the closing-in and in the zone of direct TV communication with the earth executed the docking.

"In order to avoid a rough impact, the relative approach speed at the moment of touching was brought down to several score centimeters a second" [222, pp 341-342].

Such maneuvers will be executed also by the crews of interplanetary ships. For example, upon reaching the planet Mars, when the ship will be "inserted" into the Martian orbit, a landing module with cosmonauts will separate from it, and this will descend to the surface of the planet. Upon completion of the research, the landing module will lift off and execute a docking maneuver with the mother ship.

In the docking operations of the Soyuz-4 and Soyuz-5 ships, joint actions by their crews had to be worked out. Numerous training sessions on various simulators preceded the successful execution of the operation. The process of docking was worked out both individually by V. A. Shatalov and B. V. Volynov as well as in joint training sessions. Joint actions were also worked out for the moving of the cosmonauts from one ship into the other.

After the termination of the joint flights, all the cosmonauts repeatedly stressed that the teamwork achieved in the joint training sessions helped them in successfully carrying out the complex experiments of the spacewalk and docking.

Although psychological science at present cannot provide an exhaustive answer to all the practical questions related to the staffing and training of highly efficient, psychologically compatible crews, yet, we feel, even now on the basis of theory and practice it is possible to outline the approaches to forecasting the successful activities of a crew of a multiseat spacecraft which is preparing to carry out a long spaceflight. Such a forecast should be based, in the first place, on the carrying out of experimental psychological research providing an opportunity to determine the psychophysiological compatibility for working in the "man-machine-man" system; secondly, on a psychological analysis of actions during the training period as part of the planned crew on various ground simulators and in flights in near space.

As our observations have shown, extended interruptions in work (more than 3-4 months) lead to a deterioration of the acquired skills in controlling the ship and its systems. From this it can be concluded that on interplanetary ships, evidently, it will be necessary to establish functional simulators for maintaining the skills of controlling docking, landing and other operations.

In an interplanetary flight, the crew of the ship will have not only to work together, but also to live under the conditions of extended group isolation. During a long flight sympathy, friendship and a commonness of views, that is, what generally creates a close-knit collective, assume great significance in the relationships of the crew members.

Relationships Forming in Group Isolation

> There is no drama, nothing stirring in anything except
> human relations.
>
> Saint Exupery

The joint flight of cosmonauts on orbital stations is closest to the way of life during an interplanetary flight. In truth, the duration of such flights up to now has not exceeded 84 days, while an interplanetary flight will last for years.

In order to gain some idea of the possible relationships of cosmonauts in an interplanetary ship, we have decided to analyze the relationships of people who have worked both on orbital stations and under the conditions of expeditions and polar winters. Moreover, the results of isolation chamber testing are of interest. Under each specific type of these conditions, we will be unable to find all the factors which affect a group of cosmonauts under the conditions of interplanetary flight. For example, while the isolation chamber tests simulate the extended stay of the group under the conditions of small enclosed quarters, they cannot reproduce the emotional tension which is caused by an awareness of possible failures in the work of the various systems as well as emergencies. The extended effect of weightlessness is also not simulated under these conditions. While the risk factor is present under expeditionary conditions, the complete isolation from the external environment is absent here, although in practical terms in wintering in the Antarctic during the polar night the men virtually do not leave their quarters.

Generally speaking, all the factors which will affect the crew in an interplanetary flight are represented singly under the conditions of orbital flights, expeditions, polar wintering and ground isolation chamber testing. Thus, analysis of the relationships of people which form under the various conditions of group isolation, we feel, makes it possible to disclose the general patterns with a great degree of reliability, and to transpose them to the conditions of an interplanetary flight.

From the history of scientific expeditions and polar winterings, it is possible to give many examples which show that small groups of people when confronted with difficulties and dangers unite more strongly, in their relationships they preserve a feeling of sincere concern for one another, mutual help, and often sacrifice themselves for the sake of saving their comrades. A clear example of such relationships would be the antarctic expedition led by Robert Scott.

The expedition which, in addition to Scott, included Wilson, Oates, Evans and Bowers, on 1 November 1911, left from Cape Evans to the South Pole. Having surmounted great difficulties, on 17 January 1912, the expedition reached the region of the South Pole. There, to their disappointment, they saw the waving flag which had been put up by R. Amundsen. On returning from the Pole, all the members of the Scott expedition perished, but the surviving diary entries told the world of the courage and steadfastness of these men under unbelievably difficult conditions which befell the lot of the pioneers.

Here we will give several excerpts from the diary entries of R. Scott from which the reader can gain an idea not only of those difficulties which the expedition encountered upon returning from the Pole, but also of the relationships between the expedition's members.

On 16 February 1912, Scott wrote in his diary: "The situation is severe. Evidently Evans' mind is wandering. He has completely changed. Where has his usual calm self-confidence gone? This morning and later again during the day he stopped us along the way for some empty pretext. We had cut back on our rations, but under this situation we should be able to stretch them until tomorrow evening. It is no more than 10-12 miles to the supply base, but the weather is against us. After breakfast, we were blanketed by heavy snow; we could scarcely see the ground" (177, p 366].

The diary entries marked 17 February as a "terrible day." Evans had fallen behind. While waiting for him, they set up a tent and heated tea. But he did not arrive. Concerned by his disappearance, all four ran to find him.

"I was the first to reach him," wrote Scott. "The appearance of the poor man shook me greatly. Evans was on his knees. His clothing was in disarray, his hands exposed and frozen, his eyes wild.... We raised him to his feet. He fell after every two-three steps. All indications of complete exhaustion. Wilson, Bowers and I ran back for the sled. Oates remained with him. Upon returning, we found Evans almost unconscious. When we had brought him to the tent, he was unconscious and at 1230 hours he died peacefully. In discussing the symptoms of Evans' illness, we concluded that he had begun to grow weak even when we were approaching the Cape. His condition deteriorated rapidly with the suffering caused him by the frost-bitten fingers and frequent falls on the glacier, until, finally, he lost all confidence in himself" [177, p 367]. "Misfortune does not strike once," wrote Scott on 2 March. "Oates showed me his feet. His toes are in a lamentable state, they obviously were frost-bitten during the recent terrible colds" [177, p 374].

"Saturday, 3 March.... For an hour we had made good time, but later the surface became terrible. Everything conspired against us. After 4 hours 30 minutes of walking, we were exhausted and forced to stop, having made only 4.5 miles. We have nothing to reproach ourselves for as we have pushed on with all our strength. The delay was primarily caused by the terrible way.... In our circle we are infinitely cheerful and happy, but what each thinks for himself I can only guess. Getting underway in the morning takes more and more time, and for this reason the danger increases with each day" [ibid.].

"Sunday, 4 March.... The situation is terrible, but none of us has as yet given up; at least we feign calmness, although our heart stops each time the sled catches on any snow ridge.... I fear that Oates is standing such hardship very poorly.... I do not know what would become of me if Bowers and Wilson did not show such steadfast optimism" [177, p 375].

"Monday, 5 March.... None of us expected such terrible colds.... We freeze underway when the road is hard and the wind penetrates through our warm clothing. The comrades are cheerful.... We have set the mission of playing the game until the end, without giving up, but it is difficult to strain for long hours and realize that we are making headway so slowly..., suffering from the cold, feeling completely terrible, although externally remaining cheerful. In the tent we chatter about any little thing, avoiding talking about eating...." [177, pp 375-376].

"7 March.... Quite bad. Oates has a foot in a very bad way. He is a surprisingly courageous man. We are still speaking about what we will do together at home." On 10 March, Scott wrote the following about Oates: "Oates' feet are worse. He possesses rare strength of spirit; he must know that he will not survive. This morning he asked Wilson if he had any chance. Wilson, understandably, should have said, that he did not know. In actuality, there is none.... The weather is creating lethal conditions for us. Our things become more and more iced, and it is more and more difficult to use them...." [177, p 377].

17 March: "Our life is pure tragedy. The day before yesterday after breakfast, poor Oates announced that he could go no farther and proposed that we abandon him, having put him in a sleeping bag. We could not do this and persuaded him to come with us after breakfast. Regardless of the intolerable pain, he took heart, and we made another several miles. By evening he was worse. We knew that this was the end.... Oates' last thoughts were for his mother, but before this with pride he expressed the hope that his regiment would be satisfied by the courage with which he met his death. We can all attest to his courage. For many weeks, without complaining he endured terrible suffering, but up to the end was able to talk about other matters, and did this willingly. Until the very end he did not lose and did not allow himself to lose hope. This was an intrepid soul. His end came as follows. Oates had gone to bed the preceding night hoping not to wake up. However, in the morning he did wake up. This was yesterday. There was a blizzard. He said: 'I am going out for air, and may not return soon.' He went out into the storm, and we never saw him again.

"I should say here that until the very end we did not abandon our comrades.... Now we have known that poor Oates was going to his death, and dissuaded him, but at the same time we were aware that he was acting as a noble person.... We all hope to meet our end in the same manner, and undoubtedly the end is not far off" [177, p 379].

The diaries and letters of R. Scott to his relatives, friends and the English public were found on the chest of the frozen researcher. It is impossible to read them without being moved, and without experiencing profound respect and admiration for the courage of the expedition's members. These lines relate not only tragedy but also a vivid tale of how real men should fight against difficulties.

The American admiral Richard Byrd headed two expeditions which spent the winter in Antarctica in 1929-1930 and 1934-1935. He wrote the following about the relationships between the members of the second expedition: "Our expedition was a close-knit collective of people who knew their job and those demands placed upon them, and each member of the collective worked in accord with his individual inclinations for the sake of a single, common goal. Possibly, only such a system of free comradely relationships could unite and bring together different temperaments and characters...." [27, p 69]. In another place: "And when we felt particularly fatigued and depressed, and seized by a feeling of grief and solitude, an unexpected demonstration of kindness and sincere concern illuminated the surrounding gloom with rays of warmth and light" [27, p 170].

In 1937, in the region of the North Pole, as is known, a Soviet polar station was organized. The courageous four men led by I. D. Papanin worked and lived closely under difficult conditions for 9 months. In his book "Zhizn' na L'dine" (Life on the Ice), I. D. Papanin writes that "in working on the ice, I repeatedly expressed satisfaction with the membership of the expedition. All lived amicably, they did not make any trouble, they avoided unnecessary friction, and helped one another, as Soviet people should. Of course, each man had his weaknesses and his individual human qualities, but nothing hindered us from carrying out the great program of scientific work which was entrusted to us by Soviet science and our government" [170, pp 15-16].

A notion of their relationships can also be gained by a diary entry made by I. D. Papanin on 19 July: "...Everywhere there is water up to your knees. Loathsome wetness is felt even in the living tent.... And the mood is bad due to the rainy and windy weather.... Interestingly, each of us does not let down and endeavors by joking to show his supposedly good mood. And it has become a custom for us when if one of us is in a bad mood, we suffer this silently and do not spoil the mood of others" (170, p 80].

Friendly closeness helped the six-man crew of Thor Heyerdahl to cross the Atlantic Ocean on the raft "Kon-Tiki" [sic] during most difficult and at times tragic circumstances.

Similar examples could be continued. However, the history of scientific expeditions knows many lamentable instances of the isolation of people who have fallen under the conditions of extended group isolation. Thus, the well-known researcher of Antarctica, P. Law, who headed several Australian expeditions at Antarctic stations has written: "The basic tension at such stations is of a purely psychological character. This is the tension in the relations between individual men, between groups, between the leader and the expedition members under him" [145, p 27]. Often, under these conditions, animosity and hostile feelings which develop into arguments arise among the members of an expedition. And although this is not of a mass character, it does occur, and the authors of the present book should not overlook such facts in analyzing the sociopsychological problems of a protracted flight.

During the First International Polar Year in the spring of 1881, the ship "Proteus" landed an American polar expedition led by Lt Greely on Ellesmere Land (the extreme north of the western hemisphere). At Lady Franklin Bay, wooden huts were put up at the Ft. Conger Station. A. and Ch. Tsentkevich write the following about the relationships which developed at this station: "In seeing that the men were falling more and more in despair, Greely introduced strict order and iron discipline. But this was the worst method. In quarreling during the first months of winter with his deputy he ceased speaking to him, and limited himself to giving written orders. He isolated some, ordered neglect for others, and did not try to stop the squabbles and arguments which arose over trifles. The innocent soldiers did not know for what reason they were so set upon or why all these intentions and observations were being made. Greely did not try to explain that their expedition was carrying out work under the program of the International Polar Year.... Instead of supporting those who had lost heart, dealing on a friendly basis with them, engaging them in some job, creating an atmosphere of mutual understanding and surmounting difficulties together, he resorted to a system of more and more severe punishments. Any trifle at the Ft. Conger camp now was blown up to improbable sizes, it upset the men and irritated them. Any dealings between the polar men were unpleasant and silence was unusually heavy. Greely was unable to meet the high assignment which was carelessly entrusted to him" [216, pp 25-26].

In 1898, the small vessel "Belgica" under the command of the chief of the expedition, Gerlache de Gomery, was left for the winter off the shores of Antarctica. Here is how /G. Ville/ described the atmosphere of the relationships of the crew during this winter: "21 March, the day when spring starts in Europe, in the Antarctica meant the sun disappeared beyond the horizon. The night which was to last 186 days, buried the 'Belgica' in silence, gloom and oblivion. Only the stars untiringly circled over the Pole. But they did not come up or go down. Any link with the outside world, with civilization had been broken. The 18 men who were on board the vessel to the degree they were able endeavored to provide tolerable conditions for the winter. But nothing went well for them. In the sooty cabins which were poorly illuminated by the flickering light of kerosene lamps, dissatisfaction, depression and irritation settled in. They deprived the men of mutual confidence, and poisoned the atmosphere. In other words, here 'cabin fever' found shelter, a disease which is not mentioned in the medical references" [28, p 107].

Two men of the crew of this vessel went mad. One of them, a young Norwegian, Tollefson, jumped overboard and ran off into the snowy desert. A second mentally ill sailor almost killed R. Amundsen with an ax, as Amundsen was the navigator on this ship.

The lack of cohesiveness among the men of the expedition of Adm U. Nobile also led to tragic consequences. Upon returning from the North Pole on the dirigible "Italia," on 25 May 1928, the expedition suffered a catastrophe. The nine men who remained alive out of the 16 set up a camp on drifting ice. From the history of polar research it was known that if under difficult circumstances the members of an expedition break up into groups instead of combining their efforts, then this usually leads to the loss of at least one of the groups. But, regardless of this, U. Nobile acceded to the urgings of two Italian officers, Zappi and Marianno, and the Swedish scientist Malmgram to leave the "red tent," and make their way on foot to the nearest islands. During the march of this group, an extraordinary event occurred in the history of conquering the inaccessible regions of our planet. During the trip, Malmgram froze his feet, and Zappi and Marianno not only abandoned him, but stripped the scientist almost naked and shared his clothing. In testifying before the commission which examined this infamous case, Zappi related that they "laid him in a pit which they had dug in the snow, and covered on top with snow. Nearby they had laid pieces of ice so that he could quench his thirst.... They then moved to the stronger ice which lay several score meters away.... We saw him again. He was standing, leaning on a block of ice, near the pit dug for him...." [12, p 280].

Sailors from the Soviet icebreaker "Krasin" discovered the sick and also half-clothed Marianno who also could no longer travel. Zappi had put on his outer clothing. From the confused and contradictory testimony of Zappi, it followed that he was also ready to abandon Marianno. Adm U. Nobile because of illness was the first to be removed from the ice by a Swedish aircraft. Among those left at the "red tent," the discord continued. Vilieri was appointed chief of the group. A participant of the expedition, the Czech scientist F. Begounek wrote that Vilieri had "a conceited tone whenever he spoke with me. I was irritated by this tone which obviously was the reason that Vilieri and I never found a common tongue" [12, p 199]. In another place: "Vilieri was the most unbalanced, although precisely he as the chief of the group, should have been the most self-possessed and served as an example for others.... His irritability was manifested particularly sharply in dealing with both foreigners (the second foreigner on the ice was the Swedish pilot Lundenberg.--Authors). I avoided his presence and spoke with him only in unavoidable instances" [12, p 212].

A comprehensive medical and psychological examination conducted by I. K. Keleynikov on coworkers on hydrometeorological stations (HMS) showed that "at all stations, without exception, there are more or less expressed violations in the sphere of relationships" [84, p 177].

As an illustration, it would be possible to give the psychological "portraits" of the most accepted and disliked members of the groups of the HMS. The meteorologist and weather operator S, 24 years of age, was by education an obstetric nurse. Two years previously she had married and had been recruited with her husband to the HMS where she had independently mastered the specialist of a radio operator and meteorologist. At the station, she was jokingly called the "commandant" for her efficiency, promptness and good management. She had good and even relations with all the coworkers, and was frank with all. But without showing this externally, she had a negative attitude toward one, since, in his words, "he shirked his general duties."

And here is a description of the disliked member of the group. For the last 20 years, V (he was 45 years of age) had been working under expeditionary conditions. Over these years he had held 13 jobs. He had been married but was divorced 10 years ago. He had two children but had lost contact with them. It had been noticed that in recent years he had become insulting, he had not found a common tongue with others, and felt alone. He suspected that the people around him disliked him. During a talk, with tears in his eyes, he told of strained relations with fellow workers. He constantly endeavored to create the impression of a well-read and educated person, although his knowledge of literature was fragmentary. In appearance he was sloppy. His room was also in disorder and dirty. In a sociometric study it was discovered that in the group he was "rejected."

According to the data of Keleynikov, most often among the characteriological deviations of persons rejected by a group, one discovers depression, inactivity, a low mood, suspicion, cautiousness, the inability to draw correct conclusions from the situation, standoffishness and selfishness. According to his data, among persons rejected by a group, the so-called personality profile in some instances approaches the psychopathological.

"Rejected persons" have also been encountered in arctic expeditions. In his "Ledovaya Kniga" (Ice Book) (Antarctic Diary), /Yu. Smuul/ also describes the types of such people [193].

At one of the American bases, according to the information of G. S. Mullin, four men were marked by laziness and an inclination for disputes and arguments, they did not want to obey orders, and possessed excessive sensitivity and abruptness in real and imaginary insults. They basically created a nervous situation in the entire collective [21]. Analogous examples could be continued.

Methodological Approaches to Forming the Crew

> I am convinced that if the collective does not have a goal, it is impossible to find a method for organizing it.
>
> A. S. Makarenko

The antarctic explorer P. Law has written: "Quite obviously, the choice of participants of antarctic expeditions is a task of enormous significance. Here it is essential to avoid first of all persons who are egoistic or deprived of a feeling of the collective. Conceited egoism is always dangerous.... The first and most important demand made upon a member of an antarctic expedition is a love of his job" [145, p 30].

If we turn to the history of forming expeditions in which a bad emotional climate developed, one is constantly struck by the fact that the selection of the members of the expedition was not carried out with sufficient thought. Thus, the chief of the American expedition of the First International Polar Year assigned Lt Cav Greely who was not interested in research work and who had a hazy notion of the Arctic. He was assisted by a well-known traveler who had spent many years in the countries of the tropical zone. In addition to everything else, the inexperienced leader received as his subordinates not arctic researchers or sailors, but rather infantrymen who also did not have the slightest notion of the Arctic.

In preparing the ship "Belgica" for the voyage to the Antarctic, the chief of the expedition, Gerlache de Gomery, ordered a recruiter to make up the crew, and the recruiter selected a motley horde of adventurers. In filling out the questionnaire, on the line "Experience in ice navigation," all put down one thing: "Novice."

The same situation developed in making up the crew of the dirigible "Italia." Many of the Italians prior to this expedition had never seen snow.

As we can see, careful selection was absent in organizing these expeditions. And, conversely, the expeditions were successfully carried out, where the men were selected carefully. For example, R. Scott, in being an experienced sailor, began preparations for his first expedition to the Antarctic by setting out for Norway in 1900 in order to meet the world-renowned arctic explorer F. Nansen and consult with him. It was decided to create the nucleus of the first expedition from sailors around whom the entire membership of the expedition would be united. Lt C. /Royds/ was appointed Scott's assistant. Then Lt /A. Armitedzh/ joined them, and he participated as the second assistant of the chief of the expedition. This expedition spent three winters on Franz-Josef Land in 1894-1897. Scott selected the members of his second expedition just as carefully.

In preparing for his first expedition, R. Byrd sought the advice of the famous antarctic explorer R. Amundsen. Byrd wrote: "He seriously advised me to show extreme caution in selecting the men. The men are the most uncertain quantity in the Antarctic. The most careful preparations and the most exemplary plan can be nullified by an unable or unstable man" [26, p 42]. It is of interest that the fear of "cabin fever" or "expedition madness" supposedly related to polar winters impelled Byrd to include 12 straight-jackets in the list of gear for the first expedition.

On selecting the men for the second expedition, R. Byrd wrote the following: "The murderous daily work separated the most worthy better than I. For the remaining few places I endeavored to carefully select people, taking into account the endurance of a man (during a polar expedition, endurance is one of the most valuable qualities), his achievements before the expedition, his character, and to what degree one or another man fitted the general psychological tone of the expedition" [27, p 100].

Here is what I. D. Papanin wrote about the selection of the personnel for the North Pole Station: "I knew the hydrobiologist Petr Shirshov and the magnetologist and astronomer Yevgeniy Fedorov as energetic, talented, daring and tenacious people who knew the conditions of the Arctic excellently. Regardless of their youth, these two scientists were not novices in the Arctic. They had participated in northern cruises and in the work of polar stations, and for this reason the inclusion of them in the personnel of the drifting expedition was unanimously approved.

"I knew Ernst Krenkel' equally well. He was an indefatigable radio operator and known throughout the world from the times of the cruises in the Central Polar Basin and in the work at the polar scientific research stations....

"Of my future comrades, I knew Ye. K. Fedorov best, and at that time he was still a very young person, a Komsomol member. We had worked together in 1932-1933 on Franz-Josef Land in Bukhta Tikhaya, where I at that time was the chief of a polar station, and in 1934, we traveled together to Cape Chelyuskin, where we worked until 1935" [170, p 15].

On the basis of the observations made, it can be concluded that for providing normal relationships between the crew members in an interplanetary flight, the men must be selected in a most careful manner. Such a viewpoint has been adhered to presently by many specialists working in the area of training cosmonauts and the support of manned spaceflights. It can also be judged from the reply to a journalist's question asked of the participants of a year-long isolation chamber experiment.

Journalist: "What advice would the members of this collective like to give to those people who will be under similar conditions in space, on another planet or on the earth?"

A. N. Bozhko: "There should be a very serious attitude toward the selection of the crew. Methods for such selection exist, but there still are many unsolved questions. It is not to be excluded that not the equipment will fail but rather the men or the collective, if it is not selected quite successfully. It is a good thing if at first they can live for some time together in order to 'adapt' to one another. We have carried out this practice and know that this is not always easy."

G. A. Manovtsev: "They must also have a great reserve of patience, tact and pliability. I think that all games should be given up, even chess. This can become a source of exacerbating a situation" [171, p 141].

The epigraph to this chapter includes the idea of the great pedagogue A. S. Makarenko on the purpose of a common goal for organizing a unified collective. This notion is fully affirmed in analyzing the relations between members of various expeditions who worked under extremal conditions. Here is what V. N. Volkov wrote about the purpose of a common goal in carrying out spaceflights: "Probably nothing brings people closer together than a difficult and responsible assignment. We became accustomed to one another. We shared our most secret thoughts and dreams. On the ship there was no Filipchenko, Gorbatko or Volkov, just 'We.' Although each of us continued to remain himself, we represented, as Viktor later said during one of the meetings on the earth, a single whole. Of course, we did not always share the same opinion. But we could overlook each other's faults and find a common but correct solution. All vital questions on our ship were settled by voting. As for the flight program, the word of the commander was an inexorable law for us" [30, p 156].

At present, international cooperation is developing in the conquering of space. The director of NASA, J. Fletcher, who visited the Soviet Union in 1974, called international cooperation "the only real means for realizing such grandiose ideas as the creation of a large station in a near-earth orbit, a scientific base on the moon and an expedition of astronauts to Mars."[1] The commenced international cooperation in the area of space development makes it possible to assume that the crews of the first interplanetary ships will be made up of people not only of different nationalities but also of a different philosophy. For this reason, observations on the work of scientists from nations having different social systems are of great interest for space psychology.

The Soviet scientist P. D. Astapenko spent the winter of 1958-1959 at the American Little America-5 Station at which there were also several scientists from other (aside from the United States) nations. "It must be said," he has written, "that although in scientific terms the collective of

1. LIERATURNAYA GAZETA, 18 September 1974.

coworkers of the IGY (International Geophysical Year) was not a single whole, close daily contact and the joint struggle against the difficulties and harsh nature of Antarctica united the people and brought them close together. I have the best memories of relationships among the American polar scientists who spent the winter at Little America" [10, pp 81-82].

On this same level, we should note the experience of the voyage of the sailing vessel "Ra," the crew of which included persons of different nationalities and views. Here is what Yu. A. Senkevich has written on the importance of a common goal for uniting the crew: "...But even when it seemed to each of us that the 'friendship and cooperation' on the 'Ra-1' were going rigidly, the centripedal forces in our collective were still much stronger than the centrifugal ones.

"What united us?

"Of course, above all a common goal. The goal at first was an elementary one: to make it, to show to yourself and others that you are a real man, and to reap some glory. And a material incentive also played a certain role. Abdullah, for example, had visions of paradise as after the voyage he would buy himself a taxi and hire a driver....

"The world from which we had supposedly escaped did not wish to let us alone. It regularly reminded us of it, not only in the boasting gibes of Georges, but also in the concern of Carlo about probable photographic competitors and the wonderings of Thor whether my reports for KOMSOMOL'SKAYA PRAVDA and IZVESTIYA would influence his contract with the UPI Agency" [185, p 102]. And then: "We were very different! Very! And we responded differently to what was happening to us. And who knows what would have become of us if the pressure from within our group had not been balanced by the same strong pressure from without! For all of us it was no secret that whether we made it or not depended solely upon us. Upon each of us, and particularly upon everyone as a whole. Together, always together, in spite of the frustrations, the stress, the unlimited activity and other bugbears--only together, in this reprieve was both the victory and triumph of the conception which we were to prove" [185, pp 139-140].

In summing up all the reflections on the psychological status of the crew of the "Ra," Senkevich concludes: "Lastly and most importantly, in order that the effectiveness of the group be the highest, each participant should be clearly aware of the social importance both of his own actions as well as the actions of his comrades and the actions of the entire group as a whole.... In surmounting inevitable difficulties and making inevitable sacrifices, a person should know for whose sake he is doing this; the more prestigious the mission the healthier, with other conditions being equal, the psychological climate. And prestige is understood not only as logically articulate, as this is little enough, but as 'coming from the heart.'

"The expedition group should represent a union of like-thinking persons unified and inspired by an awareness of the importance of the goal being attained" [185, p 146].

One of the most important aims motivating people in the conquering of space is the thirst for knowledge. Man has always linked the thirst for knowledge with definite feelings. V. I. Lenin has written: "Without 'human emotions' there never has been nor can there be a human search for truth."[1] In many people the desire for knowledge has developed into a passion.

An idea which has engendered passion begins to dominate in the awareness of an individual, it engulfs the entire person and subordinates the basic directions of his thoughts and actions to this idea. All the capabilities of a person seized by a passion, his will, knowledge and ideas are aimed at achieving the goal. Due to the extended dominance of an emotionally tended idea, the path for the penetration of other ideas and thoughts into the awareness of a person is blocked off.

It is difficult to imagine as dispassionate the Italian Giordano Bruno who in the name of truth mounted the pile of the Inquisition; or N. I. Kibal'chich who was sentenced to death but nevertheless continued to work on the plans for a jet aircraft; or K. E. Tsiolkovskiy who, without having a special education or the means for research work, and suffering from the ridicule of people around him, laid down the foundations of rocketry.

Equal passion and involvement are required from cosmonauts preparing for a flight. The example of Yu. A. Gagarin is an obvious one. All his amazing and brief life (he died at the age of 34) was proof of self-sacrificng service to science and his people. After his flight, Gagarin wrote: "Sometimes we are asked: why is such intense work necessary? Why do we work in such a manner knowing that generally we are working to the point of exhaustion? But certainly people confronted with an important mission or a great goal, will think about themselves and how their health is being damaged, and precisely how much strength, energy and effort must be invested in order not to damage their health! A real man, a true patriot, a Komsomol member and a communist never think about this. The main thing is to fulfill the mission" [200, p 234].

He himself never sought an easy life, but endeavored to be where things were most difficult and where he could bring greater benefit. Here is one episode from his life. After completing school, Yu. Gagarin asked the command to send him to serve in the North, where the working conditions are the most severe and demand particular skill from a pilot in piloting the aircraft, as well as resourcefulness and courage. And the feelings of duty and a thirst to be the discoverer brought him into cosmonautics. Yuriy Gagarin was a purposeful and passionate man, a great optimist who dreamed about setting foot on the moon and on Mars.

Undoubtedly, in making up the crew of an interplanetary ship, it is essential to consider the purposefulness of a person, his conviction, and his ability to surmount difficulties arising on the path to achieving the set goal. The cosmonaut V. M. Komarov could serve as an example of such a man. Dreaming

1. V. I. Lenin, "Complete Collected Works," Vol 25, p 112.

about flying since his youth, he became a pilot. Later on, as soon as the opportunity presented itself, V. Komarov applied to be a cosmonaut. However, fate was not too kind to him. Shortly thereafter he was admitted to the hospital where he underwent an operation, the consequences of which left his further preparation for a spaceflight in doubt. Unusual tenacity was required not only to begin training and to catch up with his comrades 6 months after the operation, but it was also essential to convince the physicians that he was capable of returning to the ranks.

The leader of a group of cosmonauts, Ye. A. Karpov, has written about Komarov: "He saw the leading army medical specialists. The superior chiefs received him. Everywhere he proved himself. I was phoned. It was felt that Vladimir won over both the chiefs and the medical specialists by his passionate drive for his goal. His comrades also supported him. They requested, proved and convinced that Vladimir must be left in the group.... It was decided to watch how he behaved in the training sessions" [40, pp 125-126].

Five months later Komarov became a full cosmonaut pilot, having completely caught up with the group. He was assigned as a backup man, when preparations were underway for launching the Vostok-3 and Vostok-4 spacecraft. But here also, things did not go easily for Komarov. During training on a centrifuge, a disruption of heart activity was discovered in him. He was taken out of training, and again the question arose of his fitness for the flights. However, ultimately it was concluded that these disturbances were of a temporary sort. His dream for which he had worked with such stubbornness and tenacity was finally realized. He was assigned as the commander of the Voskhod ship, the first in the world to be lifted into orbit with a three-man crew.

In remembering Komarov, G. S. Titov has written: "Volodya was among those persons who do not know fatigue in their chosen endeavor, and never lose faith in themselves. A resilient wind of resistance striking the chest constantly gives rise to a second breath which helps overcome difficulties. When such people as Volodya achieve success, it is never accidental or short-lived. In the first group of cosmonauts, Volodya was more industrious than us, and due to his knowledge, seriousness and authority he became the conscience of the collective. We recalled his favorite phrase: 'Nothing can knock us out of the saddle!' And we lament the death of our friend and comrade Vladimir Mikhaylovich Komarov. The only recompense is that he did not give up his life in vain. We are well aware that in our new successful voyages to the stars, we will be in debt to his knowledge, to his experience and to his infinite courage" [200, pp 230-231].

With a common goal, as observations in many instances indicate, differences in character and temperament do not impede psychological compatibility of the crew members, and sometimes even aid it. The 18-day flight of A. G. Nikolayev and V. I. Sevast'yanov on the Soyuz-9 spacecraft comes to mind.

The commander of the ship, A. G. Nikolayev, could be classified as having a phlegmatic temperament, while V. I. Sevast'yanov would be considered sanguine. They differed not only in terms of temperament but also in terms of their character. There is the old expression: "We seek in our friend what we ourselves lack," and probably this was most suitable to this space pair. The carefulness, neatness, great concentration and emotional control of Nikolayev were successfully combined and supplemented by the passion, drive, precise observativeness and rapid reactions of Sevast'yanov. Sensitivity, pliability, and touching attentiveness and concern for one another were inherent to these men both during the training sessions and during the flight.

Upon completing the flight, Nikolayev was asked: "For 18 days you and Sevast'yanov were face to face in a small space, far from the earth. What were the results of the flight from the standpoint of psychological compatibility, and didn't the difference of characters tell in your relations?"

A. Nikolayev replied: "Our psychological compatibility was good. On the ground we trained together for a very long time. We are old friends. We solved all the questions together, we helped one another in work with advice, and helped conduct experiments. If one person performed an experiment, the second was not idle. The difference of characters, I feel, on the contrary, was helpful. If he was as taciturn as I, we would have been silent the entire flight. But he is more talkative" [160, p 244].

In terms of psychological compatibility, the crew of the Soyuz-3 orbital station was also very well chosen. The temperament, energy and optimism of P. R. Popovich combined well during the flight with the calmness and judgment of Yu. P. Artyukhin. "Fire and ice" was how the journalists described this space team. Many years of friendship between the communists preceded this flight. "Our compatibility," related Popovich at a press conference, "was so great that even the choice of a diet was the same. And we selected, each according to his taste, separately from one another, and then in space we discovered that everything was the same!"[1]

In 1930-1931, an expedition to Greenland was organized for studying places suitable for air bases. The expedition was led by H. Watkins. A small base was founded on the "Glacier Shield," and Quentin Reilly and Martin Lindsay, men of different character and temperament, were left for the winter.

Also of interest to us is their reciprocal evaluation of one another in their diary entries. At the start of the winter, in his diary, Quentin Reilly wrote: "I feel that it will be marvelous to live with Martin. Nothing disrupts his equilibrium, and he is the most good-natured person of anyone I have ever met. A truly magnificent partner for such a game" [189, p 17]. Martin Lindsay, in assessing the results of the work, wrote in his diary: "We have always acted quite naturally, and it never required any effort to set things right. This is all the more amazing because both by temperament and taste we in essence have nothing in common" [ibid.].

In a review article entitled "The Problem of Teamwork of Small Groups in Foreign Social Psychology," R. L. Krichevskiy has written: "The desire to

1. KOMSOMOL'SKAYA PRAVDA, 21 July 1974.

explain the phenomenon of group solidarity by to what degree the members of the given group are sympathetic (a tendency characteristic for many researchers of small groups) causes valid argument" [95, p 176). We are in accord with the opinion that in making up a crew, one must not rely solely on mutual sympathy. Although we wish to stress that the choice of the crew would also be incorrect based solely on a commonness of aims, professional preparedness, the ability to work in extremal conditions, without considering mutual sympathy, similarity in views, age, interests, and so forth. If these components are not considered, then psychological stress can appear in the relationships of the crew members.

The development of tension in the relationships of people brought together by a common goal which is very important for science and working under the conditions of an isolation chamber can be better understood from the fragments of diary entries of two subjects, physicians by specialty, S. P. Kukishev (44 years) and Ye. I. Gavrikov (25 years).

Kukishev, on the 19th day: "...We have few common interests; work, reading, the diary and silence."

Gavrikov, on the 20th day: "Everything is going well in the chamber, quiet and smoothness, thank goodness. We talk little, even less than need be, and in my opinion, neither one nor the other is to blame for this...."

Twenty-first day: "I am struck by the self-control of S. P. Not once has he 'lost control,' and I obviously am not such an easy-to-stomach type." 24th day: "Our relations are interesting. I still don't understand it. At times he is unpleasant to me, and this was particularly so at the outset. And now he is sometimes even sympathetic. I could do this again...." 25th day: "S. P. says that he is in a good mood and feels fine, but also yawns and stretches just as much as me. Is he playing the fop? Still I don't understand him. We have little contact. We evidently do not get along but have accepted one another. At home I would have long ago rejected such a life together! Previously I would not have noticed this, but S. P. feels that this is so. I do not want a quarrel during our voyage on the ark. I have already come to accept the chamber, with its dull, faceless green walls, the hermetic doors, bunks and electrodes.... Suddenly I wanted a smoke. I told S. P. and he said: 'Naughty.' I don't understand him. But I repeat that I would do this again. Although perhaps because 'it is easier to accept a known evil than run to an unknown one....' It is possible to live and work with him. His mental problems are normal ones...."

Kukishev, on the 29th day: "Everything is changing, mood, perception, attitude and sensations." 30th day: "...A month of our stay in the chamber has now passed. What can I say about this? It is a completely tolerable time, and has been rather easy for me. Probably the most difficult were the first 3-4 days and from the 12th to the 18th day. Now life has assumed its own customary rhythm.... Generally speaking, our relations are still incomprehensible to me. Today I thought that they were somewhat reminiscent of two characters from 'Robinson Crusoe' after reconciliation. We, as a rule, do not quarrel. But we do not talk excessively. Generally we speak little. Possibly we have different interests, and the difference in age tells. But I, without doubt, could go another month with him. This is so. We already know when and where to compromise so that life could be normal and provide an opportunity to work normally and fruitfully" [40, pp 107-108].

From the given entries it is not difficult to see how a mental strain arises between the subjects united by the common goal of carrying out a complex scientific experiment in their mutual contacts. In order to avoid this strain, they reduce contacts to a minimum, limiting themselves to the exchange of "professional information."

If it is considered that the crew of an interplanetary ship will consist of people of different specialties, different ages, and possibly, from different countries with a different social system, it is difficult to assume that they will have a complete commonness of views, interests and so forth.

We feel that while it is virtually impossible to select persons with common views, interests, mutual attachments, and so forth for the 7-10 men of the crew of an interplanetary ship, it is essential at least to make certain that the crew consists of small groups linked by close comradely relations. The experience of expeditions shows that if this is not considered in making up the crew, then some may be "ostracized" in it.

Thus, judging from the book by E. Bishop, a member of the described crew, the Chilean Juanito who was the cook, during the first voyage on the raft "Tahiti-Nui 1" was in the position of an "outcast." His "friend" was a pig called Panchita which lived in a cage on the raft. On 25 March 1957, E. Bishop in his diary wrote: "And the sickness (meaning the mental tension in the relations between the crew members, authors) is really developing. Today after midday, Juanito, no one knows why, locked himself in the galley and would come out only to say something to Panchita. Probably he is sharing his experiences with her.... Toward evening the Chilean was sitting next to the pig. His face was gloomy, and his glance was to the horizon..., to the east..., toward Chile" [16, pp 154, 155].

Numerous works by Soviet psychologists have shown that the specific demand inherent only to people of human intercourse arises in earliest childhood, literally in the first days after birth.

K. Obukhovskiy has written that "in man, as a social being, there is a unique orientation in the psyche of other people. The beginning of such an orientation can be seen, per se, in syntony and in nonintellectual empathy which is a unique emotional contact with another person. In accord with this, the need for orientation in the emotional mood of other people must be called a need for 'emotional contact'" [165, p 159]. "Emotional contact" presupposes the existence of a two-way contact in which the individual feels that he is an object of interest, and that others are "sympathetic" with his feelings. Without the appropriate mood of people surrounding a person, emotional contact may not arise. Emotional contact, thus, is a state when a person is not only calm and confident that no one threatens him, but he also feels that he is an object of interest for the persons around him. K. Obukhovskiy, in his monograph "Psikhologiya Vlecheniy Cheloveka" (The Psychology of Human Inclinations) gives a large number of observations dealing with children in which one can clearly trace the pernicious effect of the absence of emotional contacts on the normal development of the personality.

The need for contact is particularly clearly apparent when a person becomes isolated due to geographic and other factors. Thus, William Willis who made a one-man voyage in 1954 on the raft "Seven Sisters" from Peru to the islands of Samoa (the journey took 115 days), wrote the following: "...Minutes of suffering are also related to solitude, when you are possessed by the terrible anxiety of the awareness that you live on the edge of an abyss. A person needs contact with others, he must have someone to speak with and hear human voices.... Terror takes possession of a person when he is lost in the infinite expanse of water. During the last war, many sailors floated alone over the ocean in a boat or on a raft after their comrades had perished from wounds or hunger. I have sailed with such sailors, and I know what happened to them. We said of them: 'They went mad on a raft'" [171, p 126].

In particular, this need can be seen from an entry made in a diary of one of the subjects under the conditions of experimental solitude: "Many times comrades have told me, as a joke of course, of a poor devil who lived behind a refrigerator. And in fact a refrigerator always makes some noise. In any event, I pointed out that if he would suddenly come out, I think we would have something to talk about, and I would not be against talking to him."

"The need to say something to one another," according to F. Engels, is caused, as is known, by the process of joint labor activity. But let us ask the question of what causes this need with the absence of joint direct activity?

A person constantly in his mind works out plans for the future, he analyzes certain facts, draws conclusions, and so forth. One of the causes for the need of human contact is that a person in conversation with others, in talking about his ideas, doubts, experiences and dreams, in a way correlates them with the opinions (standards) of persons in that group with which he identifies. Here, the confidant, that is, the witness of his internal world does not need to be eloquent in this contact. The nod of a head or a short reply such as "possibly" or "that is so" is sufficient, and even by these brief phrases the other person makes the necessary corrections which the person requires.

Numerous observations and experimental research have shown that extended isolation often gives rise to a false, distorted notion of oneself and the phenomena occurring in the surrounding world. We will restrict ourselves to the observation made by O. N. Kuznetsov and V. I. Lebedev under the conditions of an isolation chamber.

During his stay in the isolation chamber, we noted that subject B devoted a great deal of time to notes, that he was drawing something and making certain measures the purpose of which was incomprehensible to us.

After the end of the experiment, B. submitted a "scientific work" of 147 pages and containing a text, diagrams and mathematical calculations. This "work" was devoted to dust. The lint which had fallen out of the carpet runner in the chamber was the pretext for the work. B. had examined both the quantity as well as the ways of distribution, circulation and spread of the dust, the dependency of its accumulation upon the time of day, the operating of the ventilator and other factors. Although this "work" was a composite of naive preconceived generalizations and hurried, illogical conclusions made up in the fervor of infatuation, B. was convinced of the high value, objectivity and need of the work done by him. After the subject returned to a normal situation and became involved in customary activities, he properly evaluated his unusual conduct. Some 12 days later he even did not remember the problem of dust in the isolation chamber, and upon being reminded of this expressed obvious regret.

Contact is essential for people during difficult minutes of life, when they need support by other people. Everyone is well aware that a person most often in unhappiness does not want to feel alone. "A shared joy is a double joy, while a shared grief is a half grief," states the old saying.

Naturally, the need for advice or support can be satisfied in a group of like-thinking individuals, where a person derives not only moral and ethical standards but also finds an opportunity for self-expression. "The individual person as something distinct," wrote L. Feuerbach, "does not include the human essence either as a moral or a thinking being. The human essence is present only in intercourse, in the unity of man with man, and in a unity which rests solely upon the reality of the distinction I and you" [205, p 203]. A person not only begins to become aware of his "ego" in the process of communications with others, but, having developed as an individual, he constantly requires contact.

In the monograph "Psikhologiya i Psikhopatologiya Odinochestva" (The Psychology and Psychopathology of Solitude), O. N. Kuznetsov and V. I. Lebedev give a large number of observations showing that people who are forced for one or another reason to remain isolated (geographical, situational or social) for a long time, begin to undergo changes in mental activity which often lead to the development of mental illnesses [107]. Mental illnesses with a disruption of human contact arise not only under the conditions of solitude but also as a result of social isolation, that is, when a person living side by side with other people, in essence has no contact with them.

In the normal process of intercourse, there must be not only mutual understanding but also the ability to adapt to one another, that is, to show pliancy. The Australian antarctic explorer Philipp Law includes this quality as an obligatory requirement for the personality of arctic explorers. "The second important condition," he writes, "is not merely the absence of egoism, but also an attentive attitude toward persons around, and the ability to consider the opinion of other people as well as their sympathies and antipathies and shortcomings" [145, p 30].

V. N. Volkov has written the following about the same thing, but rather in terms of spaceflights: "The future spaceships, and particularlay the orbital stations with an extended existence, will be staffed by an entire collective of people. This collective will include astronomers and meteorologists, geographers and cartographers, physicians and communications workers and many, many other specialists. And it is very important that these people understand each other excellently, that they can forgive one another for minor mistakes and weaknesses, and respect in each person his feeling of own dignity, and live in concert with the others.

"What at times is tolerable in human relations on the earth is completely inacceptable in space. I recall the flight of our three-man crew. During the entire flight, in order not to consider the most insignificant details, we worked as one person, trusting and helping one another. And this, undoubtedly, helped us in carrying out the flight program far from our relatives, dear ones and friends" [30, pp 169-170].

However, as the experience of many participants of different expeditions has shown, precisely here the difficulties more often arise. For example, according to the data of a questioning of participants in the American antarctic expeditions conducted by the American scientist /G. S. Muliton/, the necessity of adapting to individual persons was the main reason of their tense state.

Bozhko writes the following about the relationships of the subjects in a year-long ground isolation chamber experiment: "The relations between us became more even. We tried not to give each other 'advice,' and to be correct. Since none of us wished to be isolated among the other three, that is, in absolute solitude, we all began to think seriously of the relationships....

"In our relations there appeared a guiding and solely acceptable principle for all of us, that is, not to interfere into the affairs of the other in either word or deed, and if an extreme necessity arose of interfering, then it was best as a cautious action (to do something for a comrade) than by word. Under our conditions, a word was too strong a stimulus. It might not completely convey the sense or distort it. For this reason, in talking we endeavored to be extremely careful. We answered each other's questions briefly. We developed in ourselves the ability not to respond to unpleasant replies or to respond not at once, subordinating feelings and emotions to judgment. We endeavored to formulate the sentences before saying them, and generally tried to talk less. We spoke only on professional or neutral subjects. German was the most taciturn. This was one of his traits which I liked.... As little as it took, particularly under our conditions, to disrupt a person's mental equilibrium, even less was required for him to smile.... It was also important to spare the dignity of the other person, not to encroach on his self-esteem, and to select the proper form of contact. And how great the role of politeness is as sometimes only it helps to settle successfully disputed questions" [18a, p 89].

In another place: "Now we have worked out our own particular ethics of conduct and mutual contact. A hook for clothing which is used by one person is not taken by another. This is not simply tactfulness, but rather a desire to maintain the achieved equilibrium in relations and to maintain it by all our forces" [18a, p 39].

The ability of a person to dispose others to him also contributes to the successful organizing of reciprocal relations. Yuriy Gagarin possessed this amazing ability. Each person who had contact with him felt the charm and fascination of his personality. He quickly found a common tongue with persons of different age and professions. The openness of his soul and the absence of cleverness made it possible to feel at ease and comfortable with him, while his inclination for joking encouraged optimism.

Generally speaking, a sense of humor is very valuable for the members of a spacecraft crew. In turning to the USSR Academy of Sciences with the request to select a doctor for the crew of the ship "Ra," Thor Heyerdahl made two conditions: "He should know a foreign tongue and have a sense of humor!" Subsequently, T. Heyerdahl wrote about this seemingly surprising request from the standpoint of "serious" persons: "I wrote nothing about the medical skills, since I have no doubt that the Academy of Sciences would choose a first-rate specialist. I said nothing also about the fact that the person should be strong, healthy and bold, as all these qualities go without saying. That is why I limited my request to selecting a person who had a sense of humor and spoke a foreign language. Not everyone is fully aware that a good joke and laughter are the best medicine for the soul and the best safety valve for people who must spend weeks crammed together, working under difficult and at times even dangerous conditions" [185, p 3].

Many Soviet researchers of the Arctic and Antarctic have noted that joking under the conditions of an expedition makes life easier. It helps to release tension in very critical situations and encourage a down-hearted comrade. "The Arctic does not like gloomy or unsmiling people," wrote P. D. Astapenko. "It is difficult for such people on the ice, and it is even harder for others to live with such people on the ice" [10, p 88].

Americans who watched the work of Soviet polar explorers at the Vostok station "were amazed by the good, happy mood of the Soviet people; they were constantly laughing, singing, joking, and encouraging one another in loud voices."[1]

Astapenko has noted that joking was also very popular at Little America (Antarctica), where life was filled with intense and dangerous labor. In 4 years alone, from 1956 through 1959, 17 Americans lost their lives in

1. NEW YORK TIMES, 26 February 1964.

various accidents in Antarctica. "They were all young fellows," wrote P. D. Astapenko, "sailors, tractor drivers and pilots--the same smiling Americans whom I was accustomed to see as my winter comrades at Little America.

"I recall when two tractor drivers were brought to our station who had fallen through a fissure in the ice with their tractor and the attached sleds. They were pulled out from a depth of 35 meters and brought to our sick bay. Several days later they were already back at the mess where their comrades showed them all sorts of attention, but not by an expression of sympathy, but rather an approving smile, a light clap on the shoulder and a joke, that is, in every manner that could lift the mood or help ease the physical suffering.

"You could hear the attitude taken toward the injured men in the question: 'What, Phil, you weren't able to drill a hole through to the shelf with the tractor?'

"And the answer was in the same joking tone: 'The sleds stopped us, but now Jim and I know exactly where the ice ends and the water starts.'

"Both the questioner and the answerer laughed and were content; the other persons present in this conversation also smiled.... Thus, the men in Little America laughed among the ice and this laughter sounded quite natural, it helped shorten time and made life easier" [10, p 89].

Jokes and humor are constantly present in spaceflights. Thus, the American astronauts who were present at training sessions at Zvezdnyy Gorodok during the flight of the Salyut-3 orbital station, sent the following radiogram to P. R. Popovich and Yu. P. Artyukhin: "We, your space colleagues, congratulate you on your great success and are waiting to meet you at the baths of Zvezdnyy Gorodok after your safe return." The Soviet cosmonauts replied: "We will willingly meet at the baths. Get the kvass and wreaths ready."

During the first days on the Salyut-3 orbital station, the cosmonauts began to miss things. Popovich informed the earth: "We have a gremlin on the station. My athletic gear has disappeared." The earth replied: "Look for a small dark thing." The cosmonauts found it, and it turned out to be the ventilator. The problem was that any article not fastened down could be in any place of the station, particularly with the movement of air caused by the ventilator. The cosmonauts found all missing things in the area of the ventilator.[1]

Of course, it is certainly not compulsory that all the crew members possess the ability to laugh and joke in any situation. "I cannot imagine a collective," wrote A. S. Makarenko, "made up of gloomy people. There should be at least one cheerful person or one wit." He felt that in a balanced collective there should be persons of varying character, including "a very severe person who never smiles, who never forgives anyone and whom it is impossible not to obey" [147, pp. 132, 133].

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1. IZVESTIYA, 11 July 1974.

This notion of Makarenko's, we feel, is substantiated in an interesting observation of Yu. A. Senkevich. "Sometimes I wonder," he writes, "if one had to choose between Georges and Carlo for the expedition, who, if I had my way, would I take? Carlo is a magnificent fellow, and so is Georges. Carlo is unusually industrious and without any doubt works more than all the others on the 'Ra.' Georges is particularly good wher- he can show himself and perform miracles of heroism, but would just as s... forego daily duties. Carlo always proudly turns down help, while Georges accepts it happily. Carlo seeks out the duties of others, and he is litearally afraid that the neighbor will do a bit more. Georges is quite happy if it seems that he has outfoxed his neighbor. Carlo is a serious worker while Georges is an amusing buffoon. But whom of the two would I take on the 'Ra?' I don't know. It would be a difficult choice and I am quite glad that I don't have to make it. I am fond of Carlo Mauri for the fact that he is such a strong man, and I am fond of Georges Sourial for the fact that he is such a disorganized and careless person. For an expedition, it seems to me, it is equally essential to have Carlo with his implacability, with his whole and dependable character, and Georges who can amuse one at any moment, who helps by joking smooth off the rough edges, and for a person so wishing always provides rich grounds for criticism and moralizing as there is someone on whom you can unburden yourself" [185, p 87].

What should be the personality of a cosmonaut preparing for an interplanetary flight? He should be a person of high ideals, purposeful, self-reliant, a collectivist, with a pleasing character, physically enduring, and should have a sense of humor, and so forth. Of course, all these qualities in each crew member can appear with varying expressiveness and in different combinations.

We have not taken up the procedures for studying the personality of the cosmonauts who would be selected for the crew of an interplanetary ship. Undoubtedly, over the next 10-15 years these procedures will be significantly improved, but it can be said with confidence that selection is only the initial period in forming the close-knit crew.

As we have already pointed out earlier, a group of people is like a living organism. It, like any organism, is born, develops and dies a natural death or as a result of its "illness." A. S. Makarenko was the first to describe the development dynamics of a collective, having established several stages in this.

The first stage is characterized by the creation of the crew. In this stage, the leader, in following the regulations and instructions, places demands on the members of the collective. In the second stage, the activist group which supports the leader, begins to function. And, finally, the third stage of development begins when the collective places demands on the individual. "This is the result," writes Makarenko, "which remunerates us for the nervous labor of the first period. When the collective requires, and when the collective has been shaped in a certain tone and style, the work of the indoctrinator becomes mathematically precise, organizational work [147, p 195].

The formal structure of the group reflects the relationships of the people in terms of a professional or functional principle. Here the relationships are regulated by the set standards which have been put down in the regulations, instructions or manuals.

An informal (unofficial) structure of the collective develops along with the formal one. In the informal structure of the collective, the relationships are based upon the principles of personality relationships, that is, sympathies or antipathies, trust or mistrust, gratitude or negativism, and so forth. The informal structure of the group is a system of emotionally tended ties between its members. It is focused inside the group, on its members and their personal qualities, while the official structure is turned toward the outside, that is, to the task of activity.

The need for human contact is the internal basis for the personal relationships between the people in the informal structure. Here, in selecting a partner for contact, such qualities as physical strength, intellect, morality, energy, attractiveness and other individual qualities have a substantial influence. Dealing in informal relations, the people have an opportunity to manifest their individuality by a comparison of their forces, abilities and merits with the analogous attributes of the other participants of the group. As a result of this, some persons acquire more influence and others less, depending upon their individual qualities.

The formal and informal group structures are in a dialectical unity and clash. The balancing of this unity also determines the solidarity of the group and its collective psychological abilities for effectively solving the problems confronting it. In well-organized collectives, the formal structure is dominant in regulating the informal relations. And, conversely, where informal relations begin to prevail, the principle of professional contacts begins to recede into the background and is overshadowed by the principle of personal interest.

The Soviet scientist Ye. Bidlov [29, p 210] represents the development of a group structure in the following manner. The first stage is the existence of a group with a separate and disorganized structure, without subgroups. The members of the group know little about one another. The process of interrelations is based chiefly on interaction according to professional principles. The unofficial ties are weak and unstable, and crisis situations and tendencies for misunderstanding and conflicts often arise. Under the condition of sufficient interest on the part of the group and the results of its labor within the group structure, an intensive process of human contact occurs. It is aimed at disclosing for each member of the group the optimum and customary forms and styles of interrelations, mutual influence, perception and mutual understanding.

The second stage is the rise of a group with a central informal structure, without subgroups. As a result of the already sufficiently developed relationships, the personal positions and weight of each group member are determined. The reciprocal and self-assessment network of the group is determined.

In the structure of the group a nucleus (one or two persons) arises which begins to have the greatest authority and unofficial influence. There is a centralization of relationships and preference for this nucleus on the part of the other group members. Definite trends are noted in the movement of certain members to the structure nucleus, and others to the periphery. The range of interaction among the group members and its intensity grow and are systematized under the regulating influence of the group standards and controlling documents. The effectiveness of solving group problems in many ways is determined by to what degree the status of the official group leader coincides with his unofficial status.

The third stage is the rise of a group with a centralized structure and subgroups (groupings). The development of relationships leads to the drawing of the people closer together. Then groups of psychological coalition of two-three or more members arise. Each such coalition is distinct in its high uniformity of behavior models and positively tainted emotional-attractive ties. In their contact, the groupings are oriented to the structure nucleus. Informal leaders appear, and the figure of the formal leader may also be among them.

This general development pattern of any group has also been expressed in isolated collectives. In speaking about winters in the Antarctic, R. Byrd has written: "Among us, as everywhere, it was inherent for the men to form into groups which arose spontaneously as a result of a commonness of tastes, views, habits and character. Here, no alienation or hostility was noted in relation to the other comrades, and this was in no way intended" [26, p 246].

We find one of the vivid descriptions of the structure of such informal groups under expeditionary conditions in the book of Yu. A. Senkevich.

On the vessel "Ra" during the voyage three informal groups were established. The first included Carlo Mauri, Abdullah Djibrine and Thor Heyerdahl. In describing this group, Senkevich wrote: "Whatever Thor was doing, his faithful Sancho Panchez, Carlo, followed him like a shadow. If Thor was doing some carpentry, Carlo handed him the tools, and if Thor was planning on photographing, Carlo carefully cleaned his camera.... Here there were no ulterior motives, as Carlo did not gain any benefits for himself, and on the contrary, Thor pestered him more than the others. Simply Carlo profoundly and loyally loved Thor, and Thor repaid him in kind, and their relationship was an example of friendship in which one inobtrusively dominated while the other was ready to assume a subordinate role...." [185, p 96]. During the voyage, Thor took charge of Abdullah Djibrine. For the African who did not know English, Thor was not only the commander but also the protector. Generally speaking, Senkevich wrote, for him Thor was almost "the only ray of hope, and such a situation was to the liking of both, as it helped Thor control Abdullah, while it brightened the vicissitudes of raft life for the carpenter from Lake Chad" [ibid.].

The second stable group was formed by Norman Baker and Thor Heyerdahl. In this expedition Norman performed the duties of navigator and radio operator.

In sitting in front of the radio equipment in the semidark hut, Norman sometimes was able to talk with his wife, children and friends, and this put him in a somewhat privileged position.

The third group included Santiago Genoves, Yuriy Senkevich, Georges Souriel and Thor Heyerdahl. In describing his subgroup, Yu. Senkevich has written: "Who knows what brought us together? Possibly, age was not of least importance. Georges was certainly young, I was relatively so, and as for Santiago, regardless of his 45 years, he was a glorious fellow, and there was no other way to describe this expansive and active fellow....

"We were brought together by our joint ship duties, and we tried to stay together during our free time. We would stretch out on the deck of the hut or on the bow and talk and joke. Norman, attracted by our loud voices, would fly into anger.

"'What are you doing here?'

"'Blowing in a sail! Come and help!...'

"This was the third group, Santiago, myself, Georges, and, certainly, Thor.

"It should be noted that on the 'Ra' there were three subgroups, more or less separate, and Thor was part of each of them. We were lucky with our leader" [185, pp 97, 98].

T. Heyerdahl made certain that none of the participants of the multinational crew was left in social isolation. He paid particular attention to the African Abdullah who knew only Arabic and was painfully aware of discrimination against him as a black. "Thor," wrote Senkevich, "was the most tactful among us, and magnificently understood the complexity of Abduallh's position on board the 'Ra.' He was very attentive to the African, and was always on guard and ready to smooth over a situation and avoid difficult moments. Thor asked Georges, the only one who was actually able to do so, to talk more often with Abdullah in Arabic in order that he not be alone and become depressed. Georges decided to teach Abdullah to read. The student took to his lessons with energy, and this amused both him and Georges, and this was also important" [ibid., p 95].

Adm R. Byrd has written the following about relations between officers and the rank and file in his expedition: "Different human properties were also felt in the group on the 'Larsen.' Of the 14 men traveling with me, only one, Russel Owen, called me by name. I even had to rebuke an officer for high-handed dealings with one of the expedition members who was a simple soldier. This officer cannot be blamed as he had not yet had time to accept the notion that in our expedition there were no privileges. In such an undertaking there is no room for social differences" [26, p 34].

On this same question, P. D. Astapenko writes: "Little America, in terms of the composition of the predominant majority of winterers, in terms of way of life, principles of organizing labor and recreation, was a U.S. naval station with the inevitable dominance of one-man leadership and military discipline. However, here, due to the specific conditions of the arctic winter, in one way or another a great deal was done in order to create a certain appearance of fraternal relations between the winterers who were equals outside of service. In the mess and club, an atmosphere was maintained of universal equality, regardless of age, service or other differences among the individual groups of polar workers" [10, p 93].

On the basis of research conducted during antarctic expeditions, it can be asserted that, as a rule, the entire above-described development dynamics of a collective is also inherent to the conditions of an expedition. Thus, V. V. Boriskin and S. B. Slevich have noted: "On the basis of Soviet and foreign experience and the sociometric evaluations, it can be asserted that the cohesion of the collective, as a rule, goes through four stages. In the first, the collective is not yet consolidated, in the second, various groupings are formed, in the third, consolidation occurs around a formed nucleus, but solitary individuals still remain. In the fourth, one can note the breaking up of the collective most often into individual age groups which are not of a functional sort. As a whole, by the end of the winter, the state of morale in the collective was higher than at the very outset [21, p 36].

We feel while such a practice to a certain degree is practical and acceptable for making up antarctic and other types of expeditions, where it is possible to replace members, it in no instance is inacceptable for long spaceflights. The crew should be completely gomphoteric, that is, "put together" before the flight.

The experience of expeditions shows that in the process of the dynamic development of a group, there may be a decentralization of the formal and informal structure, with the separating of groupings which divides the collective as a single whole.

In the book by F. Begoupek "Tragediya v Ledovom Ckeane" (Tragedy in the Arctic Ocean), it can be seen that the forming of a subgroup with an informal leader preceded the splitting up of the expedition. The author writes: "The initiative of leaving the place where the victims of the accident sooner or later would inevitably perish, undoubtedly, belonged to Zappi. From the very outset of the stay on the ice floe, he was nervous, he was constantly irritated and quarreled with everyone. His excitement was further intensified from the very moment when an island was first spotted on the horizon and when the change in the coordinates of the camp indicated that the ice was constantly moving to the southeast into the open sea. Marianno anxiously followed the mental state of his friend. He met him halfway on every point, forgetting the duties which he had accepted for the collective, having taken over for the commander who was unable to get about, as Marianno from the very outset of the expedition was the official deputy commander" [12, pp 82-83].

During the second voyage which ended tragically for E. Bishop, when the raft "Tahiti-Nui 2" gradually began to lose its buoyancy, his crew split into two groups. Three crew members demanded that the food and water be divided up. "In the evening," related the deputy chief of the expedition, Alan Bran, "when everything had quieted down, I again endeavored to get it into their heads that possibly we would have to remain at sea for another month, and for this reason the strict distribution of the supplies was extremely necessary. I endeavored to convince them that a catastrophe would certainly befall us if each man would take his share then....

"Eric (Bishop, who was gravely ill, authors) recommended to me a simple and enticing method of maintaining discipline on the raft. Give all the recalcitrant crew members a good thrashing, and if this did not help, simply throw them overboard. But I was afraid that Eric and I would be the first overboard, and only this kept me from employing the old, tested methods. I endeavored to find another way of solving the question which had arisen, but I had to think everything through calmly during the evening watch at the helm. And I soon concluded that my situation was hopeless. Three comrades had reached agreement against me" [61, pp 167-168].

Here, obviously, it is wise to note that as the ocean is reflected in a drop of water, so the relationships of the people of that society of which there are citizens are reflected in an isolated group. Involuntarily one compares the situation on the raft "Tahiti-Nui 2" with that on the Soviet self-propelled barge which at the start of 1960 during a storm was driven off the coasts of the Kurile Islands into the open ocean. There were four soldiers on board: Astakh Ziganshin, Filipp Poplavskiy, Anatoliy Kryuchkovskiy and Ivan Fedotov. After a 49-day drift, they were picked up by an American aircraft carrier and brought back to San Francisco. Their feat amazed the entire world. But probably the people of the bourgeois world were most amazed by the feeling of solidarity which the Soviet soldiers showed under these conditions.

All these examples again affirm the notion that the crew of an interplanetary ship should not only be made up on the basis of careful selection, but should go through all the stages of its development long before the flight.

In the process of this development, there should be a maximum merging of the formal and informal structures into a single whole. This merging can be expressed externally in the successful fulfillment of a set program, and internally in the satisfaction with the contact of participants with one another and in the satisfaction in their work. In particular, the effect of such a merging will also consist in the fulfilling of the standards and demands by the people without internal psychic stress.

In ending this chap er, we would like to endeavor to answer the question of whether there is a guarantee that psychic stress which could grow into a conflict would not arise between the crew members made up on the basis of car ful psychological selection and which had gone through all the stages of their development to a close-knit collective in the event that extreme conditions occur?

The following observations help us answer this question. For several years, N. N. Miklukho-Maklay and Ernst Gekkel' were linked by common scientific interests and personal friendship. Together they set off on an expedition to the Canary Islands. After a scientific argument under expeditionary conditions, the two scientists established strictly official relations. "They," M. Kolesnikov has written, "were no longer photographed with their arms over each other's shoulders, and did not talk about the mysteries of the universe. Everything somehow became lackluster and irritating. Gekkel's patience gave out. Enough! he said at the end of February. Let us turn back to Morocco. Thus, after 3 months of living on the island of Lanzarote, a whole month ahead of time, the expedition left the Canary Islands" [88, p 52].

Another example of this would be an episode from the life of the remarkable polar explorer F. Nansen related by him in Edinburgh during a lecture entitled "What We Do Not Write About in the Books." Having drifted on the vessel "Fram" to the 84th parallel, he along with his great friend Johansen, left on skis for the North Pole. Having reached 86°41' north latitude and having realized the futility of their efforts, they turned south. After almost 18 months they reached Bol'shaya Zemlya. They walked across heaps of ice hummocks and floes in icy clothing which they could not dry out. Nansen had rubbed a large wound on his arm from a frost-frozen sleeve. They ate walrus and polar bear meat. With the warmth of their bodies, they warmed flasks with snow in order to drink. But the most difficult thing they had to endure during the winter on the islands of Franz Josef Land in 1895-1896 was their personal relations. The former friends became so irritated with one another that they virtually stopped talking. They spoke to one another extremely rarely, sometimes once a week. And these words were of a strictly official character such as "Mister Expedition Chief" and "Mister Chief Navigator" [22, p 179].

As for the participants of long isolation chamber experiments who have undergone psychological selection for compatibility, it must be said that an emotional stress in their relations was also noted. Let us give several such examples. Thus, in 1964, A. V. Lebedinskiy et al. [129] published the data of a 120-day experiment conducted under the conditions of an isolation chamber. Three men participated in it. In the course of the experiment, deviations were noted in the neuropsychic state of the subjects. These changes came down to increased irritability, as a result of which conflicts arose more often than in an ordinary situation.

Emotional tension was also present among the subjects who participated in a year-long experiment in a ground-level complex. "Disputes," writes A. N. Bozhko, "are a very unpleasant and serious phenomenon in our life. We all try to avoid them, but still it is very difficult to hold oneself back" [18a, p 91]. In the report of the psychologists who participated in the year-long experiment, it is stated: "There were periods of difficult relations and sometimes minor conflicts among the testees. And they arose over the most insignificant pretexts. For example, minor domestic matters were such a pretext. It also happened that periods of hostility toward one another at times reached 'blind hate' and 'physical revulsion.' At such times, the close contact and the impossibility of being physically isolated from one another were a particularly severe trial" [18a, pp 39-40].

Thus, from the given observations it may be concluded that the needs of cosmonautics pose not only the problems of psychological selection and the uniting of the crew, but also the problems of preventing psychic stress in the relations of the men.

CHAPTER III: CAUSES OF PSYCHOLOGICAL STRESS IN THE RELATIONSHIPS OF PERSONS WORKING IN ISOLATED GROUPS

Quite understandably, for working out any recommendations for preventing psychological stress and the occurrence of conflicts in small isolated groups working under extremal conditions, it is essential to disclose the factors which cause them.

The process of relations in small isolated groups is a complex socio-psychological phenomenon. In conducting analysis and isolating individual aspects in this complex dynamic process, we are quite aware that we are doing this in a simplified and schematic manner, but obviously this is indispensable.

The Effect of Asthenization of the Nervous System on the Process of Human Contact

> Of course, the strongest stimuli are those coming from people. Our entire life consists of the most difficult relations with others, and this can be felt particularly painfully.
>
> I. P. Pavlov

One of the conditions for successful relations is, as certain foreign psychologists have assumed, a mutual understanding by the partners, and this, in turn, is achieved by the ability to assume the role of the partner. "The assuming of the role," writes T. Shibutani, "is a complex process which includes the perceiving of gestures and a substituting identification with the other person and a projection onto him of one's own behavior tendencies. Identification is inseparably linked with communication, for only having imagined oneself in the place of another can a person guess his internal state. In remembering his own humiliations, triumphs and losses, he can feel close to the other person in analogous circumstances. Thus, conclusions on the internal experiences of others are the projecting of one's own externally unexpressed acts. In hearing the speech of the other person, each person can participate in the flow of his thoughts. People are able to understand the actions of one another by coparticipation" [224, p 123].

The ability of a person to comprehend the behavior of others is limited by his culture and personal experience. The wider the range of roles in a person, the easier it is for him to understand another person. Although the process of putting oneself in the role of the partner is not always realized by us, it in actuality does occur in any human contact. For example, when we are conversing, before replying, with our imagination, we endeavor to penetrate the world of our partner's experiences and imagine what effect the sentence being readied will have on him. We judge the reaction of our partner from the intonation of his voice, gestures and facial expressions, as well as from a number of autonomic reactions (pupil reaction, the character of breathing, rapidity of speech, and so forth). On the basis of the subconscious analysis of this information, we not only judge the emotional state of our partner, but in accord with the mechanism of imitation, we begin to experience this with him. In turn, the partner, in assuming the role of the other, anticipates what response is expected from him. In the opinion of the American researcher G. Mead, when this "anticipating penetration" of one into the other occurs successfully, a growing friendliness appears among the partners, or a feeling of "empathy." In the same instances, when this does not occur, the process of human contact is disrupted.

The physiological mechanisms of an integral system consisting of two or more persons in contact were described in the form of hypotheses in 1930 by the Soviet physiologist A. F. Samoylov in the article "The Circular Rhythm of Excitation," where he wrote: "When anybody...looks at a living person and talks with him, then both these persons form together a system of rings through which the excitation runs.... A lecturer giving a lecture and endeavoring from the appearance and conduct of the listeners to grasp how the lecture is being received and the listeners trying to understand the words and the sense of the lecture together form a single whole, one system of circular excitation" [183a, p 146].

The process of human contact with a "circular rhythm of excitation" can be disrupted by "breaks" both in the first and second signal system. For example, once I. P. Pavlov was shown a patient who described his illness as follows: "...Relations with people always cause great difficulties for me, and as a result of this the occurrence of certain conflicts" [167, p 160]. In explaining this case, Pavlov provided the following explanation: "This is a wonderful case. Understandably, in one way or another our relations with the people around are based on the first signal system, that is, on an evaluation of the impressions which you receive, on a correct assessment.... And this is weak in him. Here analysis of this entire system is constantly required. It is essential in order to distinguish one person who is involved with me from another, a third, and so forth. This is the primary analysis or analysis of the first signal system, and this is precisely what he does not have. Hence the difficulty. He stresses that he has no trouble with an audience, if something is misunderstood, he should explain it, but it is a different matter with relations with his comrades, professors and others. For him this is difficult and unattainable. I can clearly imagine the entire problem. Correct relations are when you do not overdo it either in feeling or impression, everything in moderation, take the true measure in everything and reply properly. Thus this can be vividly imagined. With good reason a person may be called tactful, but not that he is very intelligent, that he has a very energetic second signal system, but rather tactful that he perceives the mass of impressions and has an independent response to each" [167, p 162].

During a long spaceflight, the human organism will be exposed to a number of unfavorable factors. Each of them individually, after a certain time, can cause asthenization (exhaustion) of the nervous system which, in developing gradually, leads to a disruption of personal relations.

In the seventh month of living on an ice floe, I. D. Papanin in his diary, on 30 December 1937, wrote: "To say the truth, we are tired. And this has begun to be felt in everything: both in our relations with one another and in the work" [170, p 247].

Mario Mare wrote the following on the asthenization of the nervous system and the deterioration of relations among the people who spent a winter in a single barrack: "You felt like sleeping and your movements were feeble. I can explain this by the absence of comfort and the varying rhythm of activity to which we had become accustomed.... I was more and more convinced of how important coziness is during polar expeditions.... The mood of Bob Dovers worsened. He frequently fell into a state of depression and was irritable and grumpy.... Bob did everything he could to get rid of the blues, but from time to time they got the better of him. When he was in a particularly bad mood...he became intolerable.... He flew off the handle over the slightest trifle.... During such moments his short-temperedness became hard to endure. In such a situation, his comrades as much as possible checked him. But we knew how this would end. This would cause the irritation of some, the belittling of others and would create an impossible atmosphere. These were the inevitable consequences of living together particularly in an unusual situation, where the people were on the alert for surprises, and where inhuman mental and physical restraint was required from each" [148, pp 69, 84-85].

E. Bishop during the fourth month of the voyage on the raft "Tahiti-Nui 1" wrote in his diary: "As the head of the expedition responsible for the morale of the crew, I feel that Michele each day is becoming a more and more 'difficult case'.... God knows what may come of such a base cur, the grief which makes its way into the brain where it becomes a fixed idea! And if the area of feelings is involved, it is as good as lost!" [16, pp 135-136]. On 19 April 1957 he wrote: "I am becoming more and more petty, and am beginning to simply have no sympathy for the wretch Michele.... Of course, he irritates me...and the others. However, I should still hold back" [16, p 187].

"It is difficult to get across in words the state of the psyche," writes the Soviet and arctic explorer F. D. Astapenko, "which arises in the polar night. During these months, the persons spending the winter bear an invisible burden, and they feel a certain tension which in one way or another tells on the behavior of the people, their ability to work, their amusements and attitude toward one another" [10, p 64]. In another place: "Imperceptibly, day after day, the people little by little become worked up, and their nerves begin to give out. In the behavior of some you could sense a great strain and a certain mental fatigue" [10, p 73].

We have already pointed out how important restraint and pliancy of the people in their relations with one another are in the conditions of group isolation. The school of I. P. Pavlov has shown that these two qualities are provided by an internal inhibition which is a rather fragile process. First of all the process of internal inhibition begins to suffer with asthenization. Let us examine how the difficulties of the adaptation of people are expressed, as well as their lack of restraint and irritability caused by a weakening of the inhibition process, as described in the book of Yu. A. Senkevich.

"The further we were," he wrote, "the more constantly the 'hot spots' moved from the work sphere into everyday life. The fellow voyager was not suitable not only in how he worked but also in the fact that he was not as you would like him to be. Abdullah was a characteristic example. My diary contains many comments about him, the essence of which is that Abdullah washed with fresh water, and this was absurd. Why, particularly, was it absurd? There was enough water on board (the first voyage), and there was no limit to its use. Be that as it may, I used saltwater, but Abdullah was fastidious, and why was he better than the others? In the fact that he was Moslem? Did the Koran not command him? I recalled what the gentleman-in-waiting, Nikita Pryakhin, said in the "Golden Calf": "They all have the Koran!" When the water began to run a bit short and Abdullah was prevented from using fresh water for washing, I noted this in the diary with satisfaction: 'Good things don't last forever'" [185, p 137].

Another entry dates to those same days: "The standard is those who brush their teeth not in the morning but in the evening, and this disconcerts me." Well, under normal conditions who would base his attitude toward a neighbor on whether or not he brushes his teeth in the evening or in the morning? In another place: "And clashes as before arose, absurd and without cause. As a rule, they were nipped in the bud and resolved with laughter, but the laughter was feverish and exaggerated. Something intangible and shapeless hung over us, it whispered in our ears, it caused us to fly up over trifles, it deprived us of strength, and enveloped us with feebleness and apathy.... ...Suddenly you caught yourself wanting terribly to curse your neighbor: why was he again playing the harmonica? And you certainly understand that he also had just been working like an ox and now the music for him was a comfort, and such a pleasant justification. You understand all of this and cannot do anything" [185, p 139].

"Everyone's nerves are frayed," he writes several weeks later, "a this is constantly apparent. I am standing watch and suddenly Kei and Santiago come up to me. Kei is crying and Santiago is calming him. It turns out that Santiago pushed Kei with his foot, in a joke, but for the Japanese this is extremely insulting. Well, Kei, who knew? I am sorry, please, don't be insulted! Then Kei became angry and himself apologized and smiled through his tears: "I understand perfectly that this is stupid, but I cannot help it...." Glorious Kei, educated, self-controlled and tactful! Never during the entire voyage did he raise his voice at anyone, he helped everyone, he dealt equally with all, he was always occupied, and endeavored to serve the expedition as much as possible. And mercilessly, in protecting his comrades, he drove his own negative emotions inward, they stored up, they stored up and then took their vengeance" [185, p 171].

Analogous phenomena have also been observed in experiments on group isolation. Thus, in 1966, a 70-day experiment was conducted in an isolation chamber with a capacity of 10 cubic meters. A physician (group leader), engineer and newscaster participated in the experiment. In the course of the experiment, tensions arose in the relations of the physician and the engineer. They periodically began to get into conflicts. In truth, the program was completely fulfilled, but the participants in the experiment noted that these conflicts reflected negatively on the mood of all the group members. Here is one entry from the diary of the newscaster Ye. Tereshchenko from which it is possible to get an idea of the emotional climate in this group: "Watch, dinner, medical examination, and sleep. Our life flowed in such a feverish but monotonous rhythm. There was almost no free time. We felt that this was good and that business would drive away boredom, but.... Stass had grown noticeably thinner, was overgrown with stubble, and circles appeared under his eyes. Lenya had red eyes. More and more often it began to seem to me that a certain caustic fog was invading the tiny room and slowly poisoning us, and making us intolerant of one another. Certain trifles in conduct or in the manner of moving began to acquire an unjustifiably exaggerated importance.... The usual benevolent tone disappeared, and misunderstandings broke out, more and more reminiscent of arguments. And all over trifles" [198, p 12].

We can see that under the conditions of group isolation, psychological stress appears and conflicts arise. In social psychology, it has come to be felt that a conflict is a clash caused by the contradictions of sets, goals and methods of action in terms of a specific subject or situation. Thus, for a conflict to arise it is enough to have a difference of viewpoints over certain questions, the impossibility of satisfying various needs arising simultaneously in several persons, and so forth. The conflict itself always has a cause, but its motives for the person involved are not always clear. If one speaks about conflicts in groups, they certainly do not always need to have an antagonistic character, when the partners adhere to different viewpoints on the same problem, that is, become opponents in a debate. The contradictions of views are resolved in a conflict, and a unity of opinions is established. Thus, conflicts due to the expression of the universal law of dialectical unity and a clash of contradictions are a natural phenomenon in the development of both society as a whole as well as individual groups. Conflicts can arise within the framework of cooperation and rivalry among the members of the group united by common goals and interests.

As observations indicate, under the conditions of an expedition, a broad range of situations often arises, from accidents to ordinary life, for example, the allocating of domestic chores. It may happen that disputed viewpoints require their resolution in a collective discussion. Discussions, generally speaking, are constantly present in human relationships.

Under ordinary conditions, among educated persons, a clash of opinions occurs without coarse attacks on one another, and does not go beyond the limits of the discussed questions. In uneducated and uncontrolled persons, the discussion of a certain question or problem often gets off the professional basis into empty differences of opinion which later begin to be elevated to the status of a principle. The discussion develops into a conflict with such unjustified generalizations as: "You never understand the sense of any question," "You are not a very farsighted person," and so forth.

In a state of asthenization, in self-controlled and educated persons, the solving of one or another question often can be sidetracked from the essential to the inessential, and the entire discussion will be carried out in loud voices. An example of this would be the incident which occurred during the second month of a year-long experiment at a ground complex. In this experiment, medical research held an important place, and the physician G. A. Manovtsev was responsible for it. Once he did not keep within the scheduled time for the medical research, and decided to use an hour which at the initiative of the subjects was to be used for recreation. "For some reason, something snapped," wrote O. Siritsin about this incident, "and there you had a psychological crisis, the first outburst, a crack which could grow into an abyss.... When the microphone was switched on, the two men told the third in far from angelic voices: 'We are sick of medical research! Damn it all! You are doing this for yourself, for your own work, and you may be our leader, but we do not want to lose our hour of rest.... Lastly, be so kind as to keep to the schedule and don't prevent others from leading their lives. We do not want to suffer because of your interests, and you know what you can do with them! You should consider us! You are not right!'

"'Why are you resting at the wrong time? Why?'

"'Why do you use your 'official position' against our interests? You know that we are tired and there is nothing wrong if we rest an extra hour....'" [187, p 51]. The conversation was carried on in loud voices. Both parties felt they were right. The complaints were stated with certainty, but the double-edged conversation did not lead anywhere. Relations became strictly official, and conversations were limited solely to the range of working questions. Then followed a truce which after a certain time was again violated.

The alternation of normal relations with a disruption of them has also been noted by certain polar researchers. Richard Byrd has written: "Show me a group of people which would live as we have and among whom complete harmony reigned for an entire year, and from whose lips came only sweet words for one another, and I will have the dubious privilege of seeing virtuous puppets and not people made of flesh and blood and given nerves" [26, p 276].

It is not without interest that in summing up the year-long experiment on the ground, it was stated that after each conflict, the neuropsychic state of the subjects improved, and this was reflected in an improvement in the experimental psychological tests. A number of polar researchers have also noted that after the mutual complaints have been voiced, an emotional detente occurs. In particular, C. Borchgrevink has written: "I do not know how we could have tolerated the long polar night, if these small quarrels had not arisen...." [23, p 94].

Yu. A. Senkevich has the following to say about the "letting off" of accumulating emotional stress caused by the uneven distribution of the workload: "We met and took our places, ready to maintain the tradition, politely congratulating one another, but the proper tone was not there. Something literally hung over all of us, either the pain associated with the water, either the fatigue, or that we had all become, alas, older and indifferent, and the 6 months of enthusiasm were replaced by habit. In fact, we no longer felt to be pioneers, but rather regular travelers, not poets, but rather artisans of the ocean....

"And Santiago still called Georges in a whiny high voice, and he previously had joked and teased so much, but today Georges got angry, the persons around instantaneously were set off and a scandal developed.

"I will not describe it, and I will not re-create our more than hour-long discussion, as it concerned the standing of watches, help in washing dishes, the shirking of work, and, conversely, being late for meals and using the towels of others. This was an excellent international brouhaha in which Italian expansiveness was successfully combined with Mexican venom, while American straightforwardness was outshadowed, if you will forgive me, by Russian folklore. The tactful Kei merely blinked his eyes, Madani, in despairing of understanding even anything, rolled himself into a ball, while Thor bit his lips. In his place I would have long since rapped the table, but he did not intervene, allowing us to shout ourselves out.

"This was the first time that we had 'conversed' with one another in this manner. And when the heat of the polemics reached the highest point, when it seemed that fists would be flying soon on the deck of the 'Ra,' suddenly everyone fell silent. And suddenly all of us together and each person individually saw what rubbish was bothering us. Over a mere trifle, over cigarette butts and dirty dishes we were squandering our expedition, our glorious ship, our male community born in hard work, to the whistling of the wind and the roar of ocean waves. Each person glanced at his neighbor and smiled embarrassedly. And laughter broke out, therapeutic, cleansing, like a May thunderstorm.

"Santiago clapped Carlo on the shoulder, Norman jokingly poked me in the ribs, Georges scampered up the mast for the champagne, and a feast started on the 'Ra-2'!

"We broke up only at 0200 hours, an incident generally unheard of in both voyages. We drank, ate, drank again and talked, we talked like we could not talk enough, as if we had met after a long absence.

"Yes, that generally was the case. The barriers came down, barriers which were erected for unknown reasons and which separated us, the dots were put over the 'i,' relationships were settled, and the holiday which had started awkwardly and unpleasantly, offered us in fact a precious surprise" [185, pp 128-129].

Many disputed questions have also been resolved in the discussions of spacecraft crews. V. N. Volkov has written: "It would be incorrect to say that everything went smoothly, without breaks and without disputes, for us. All sorts of things happened. There were insults, and arguments until we were hoarse...." [30, p 108].

On the questions of analogous situations in the year-long experiment, A. N. Bozhko has written: "Such 'disputes,' although unpleasant, are good in clearing away the situation, for they, in being the cause of differences of opinion, become a pretext for a conversation.... After them relations are always more relaxed, the unvoiced ceases to be a burden, and the mood is immediately improved...." [18a, p 109].

In the past century, the polar explorers often used alcoholic beverages during the winters to release emotional tension in human relationships. Here is what Borchgrevink writes: "We had pleasant evenings, when grog was served. This immediately improved the atmosphere, and I concluded that the occasional use of grog or wine had a remarkable effect on the expedition members. The doctor also constantly advised that a glass be issued. Certainly this was done with great care. Wine was permitted only when in the base camp. The wine was used not to warm oneself, but rather to maintain mutual friendly feelings under the conditions of our isolation from the world.... The wine affected the mood like a salubrious medicine" [23, pp 95-96].

We in no way are in favor of introducing alcoholic beverages into the diet of the cosmonauts of an interplanetary ship. Here we merely wish to stress that the ship must carry a broad range of psychopharmacological agents which should be administered by the physician with the increasing indications of emotional stress.

Experience indicates that the asthenization of the nervous system, in leading to a disruption of interpersonal relations, can arise relatively quickly in those instances when a person is exposed simultaneously to a number of unfavorable factors. Thus, on long bomber flights, the unfavorable factors will be hypokinesia (restriction of movements by the pressure suit and cockpit), continuous activities of controlling the aircraft, the threat of an accident, the altered gas composition of the breathed air, and so forth. With the effect of these factors, according to the data of the Soviet researcher V. L. Marishchuk, the dynamics of radio traffic dropped by 50-80 percent for individual pilots and navigators by the 8th-12th hour of a nonstop flight. "Due to the emotional factors of flight activity," he has written, "in individual pilots and navigators we have recorded disruptions of interpersonal communications such as impolite questions and answers, inadequate assessments of the behavior of one another...."

By the end of the orbital flight of the Apollo-7 spacecraft, the neurasthenic syndrome also appeared in the American astronauts, manifested in a disruption of communication functions. The astronauts began to argue not only among themselves, but also with the operators of the ground control stations. In talking with one of the ground stations, the commander of the crew, Schirra, recalled the death of three astronauts in a fire on board the Apollo-1 spacecraft. All the crew members, contrary to the instructions, removed the sensors for recording physiological functions. They even refused to discuss this incident with the flight leader. The astronaut Eisele justified this by the fact that on the earth "we are told fine words without the equipment, although it is good for nothing" [171, pp 162-163].

Thus, asthenization and other changes in higher nervous activity, in leading to psychological tension in the human relations in group isolation, as we see, are caused by different unfavorable (extremal) factors. Naturally, the conclusion arises of the need to work out those measures which would eliminate their unfavorable effect.

Information Exhaustion of Man

> A group in an extreme case can dispense with the exchange of material riches. But if there is no exchange of ideas, emotions and information, social contact completely disappears, as there is nothing more in common between the members of the group, and, consequently, no more community.
>
> /B. Voyenne/

The constant receiving of information from outside is one of the essential needs of man. It, in the opinion of the Soviet psychologist L. I. Bozhovich [19], is related to mental development which is carried out in the process of human cognitive activity. In contrast to all others, the need for external impressions is not satiable.

If one traces the development of a child, it is not difficult to see that the satisfying of the need for information, like other needs, is carried out in immediate contact with adults. "Any need of an infant, whatever this need might be," L. S. Vygotskiy has written, "gradually, in the process of development, becomes for it a need for another person, for human contact, and intercourse with him" [88a, p 36].

As the still sparse sociometric research has shown, for satisfying the need for information, a person, at times unconsciously, selects for contact a person who can be the source of this information. Thus, in the course of the sociometric research conducted by Ya. L. Kolomenskiy, the subjects (preschool children and young schoolchildren) were asked: "Why do you want to play (share the same desk) with so and so?" In a majority of instances, the children replied: "He tells stories well," "He knows all sorts of stories," and "He tells tales." Thus, even a young person selects those who tell stories well. It turns out that the young schoolchildren want to sit next to those who are interesting, and it is interesting, judging from their replies, when there is something to talk about. In the fifth-graders, contact is primarily conversations.

Kolomenskiy proposed that the students of one of the pedagogical VUZ's write a brief composition on the subject: "What is an interesting person?" And here are excerpts from the compositions of four female students.

"It is a person with whom it is interesting to converse on various questions, and not only those with which he is directly concerned. A person who constantly talks about the problems of his job is definitely not interesting.... This person should be a good listener. It is a bad thing when people are unable to listen to others."

"I feel an interesting person is one to whom you have a great deal to say. It is not essential that he be handsome, and he can be quite nondescript and in no way distinguishable from others. But as soon as you strike up a conversation with him, this person immediately changes. A meeting with an interesting person always brings spiritual satisfaction."

"Well, depending upon the needs of people of that society in which he lives, this person will be considered interesting among some people, and not among others."

"This person possesses those qualities which largely distinguish him from me. His knowledge in certain areas is much broader and deeper than mine, and possibly he knows what I do not know. He should not be a complete opposite" [88a, p 36].

In all the cited examples, one can clearly trace an interest on the part of one person in the internal world of the other, and the search in it for intellectual and moral qualities, that is, his spiritual richness. "Among persons," writes B. S. Alyakrinskiy, "who meet for the first time, there is a desire to get to know one another more closely, that is, a mutual interest arises, and this is one of the most positive emotions" [5, p 76].

The occurrence of positive emotions with the constant obtaining of interesting information in the process of contact, we feel, fits fully into the "information theory of emotions" elaborated by the Soviet physiologist P. V. Simonov.

During the first expedition of R. Byrd who spent a winter in Antarctica in 1929-1930, there were many interesting persons who for conversation assembled around the cot of Benny Roth which was located next to the radio hut in the mess building. "During the evenings," wrote R. Byrd, "a large company immediately assembled there, and such liveliness reigned that the corner was called 'Benny's Club.' You had only to spend a little time in the club in order to come away with all sorts of information on all the events whichever occurred in the world. Here you could listen to 'Plaster' Gould who told about maritime laws and the merchant fleet; Falken who could remember sports contests with enthusiasm; Dean Smith who could describe all sorts of stories about flights more engrossing than the most enticing novel. And often present here was our taciturn, shy meteorologist Harrison who shared his knowledge with us about the causes of weather and with unfeigned fervor discussed baseball which was his favorite passion. Often Dr Coman was also here, a brilliant scientist and excellent talker who described vividly and clearly his numerous voyages. Our doctor possessed uncommon erudition and along with Russel Owen was considered an authority on questions of literature, politics, and so forth" [26, p 247].

Byrd was clearly aware that "a day would finally arrive when no one had anything else to say to the others." And in fact, after several months, "information exhaustion" set in among the men. Irritability appeared in their relations and this assumed a tense character. "One was too talkative," wrote R. Byrd, "and by this caused dissatisfaction among his comrades, while another was sloppy. He was eternally losing what he would need in the next instant. .. A third absorbed by his own cares, with a great interest not shared by his comrades, told infinite stories from his life which were already well known to everyone" [26, p 275].

Information starvation is also noted in other types of geographic isolation such as ocean voyages. In the diary entries of E. Bishop we find the following: "Recently the mood curve of the crew has dropped. I feel that the most important thing for the voyage is cheerful spirits.... The whole problem is that we have nothing to read. All the books, magazines and abridged versions of major works have long since been read and reread. Even the stacks of old Australian newspapers have been studied from the first to the last line.... We must find a medicine against boredom...any before the disease develops...." [16, pp 147, 154].

In recalling the voyage on the "Ra-1," Yu. A. Senkevich has written: "I must say we had interesting people on the 'Ra!' And how convenient it was that we had a bench which had almost been specially made for evening chats!... And there was no cozier place on the 'Ra-1.' Now, on the 'Ra-2' instead of a heap of cans and sacks, we have a well-planned, carefully made, comfortable seat. Only the dimensions and shape have survived from the old bench. And, as sometimes happens, the store-bought toy is not superior to the handmade one, and behind the luxurious desk you write more poorly than on the windowsill, we do not sit there nearly so often as we did last year.... It has turned out...that there is less of a desire to be together. Perhaps this may be because each person knows everything else about the other" [185, pp 109, 134].

A. N. Bozhko had the following to say about information exhaustion in the year-long isolation chamber experiment: "It is interesting that the specific features of the conditions, or more accurately, constant contact have led to a situation where we have learned to understand one another without words. During the day each person will say three or four score words, and that is it.... Each of us has already told everything about himself that he could or wanted to do during the first days. What was there to talk about? But a person cannot help but talk. Certainly the word is an attribute of civilization. And at present it is vitally essential for contact. But why is it so difficult to restrain oneself and not say something 'on the personal side'? However, a word which does not carry certain information is irritating, and the person who has simply decided to exercise his speech, risks spoiling his relations with the others. Obviously, a constant exchange of fresh information is required. But what happens if it does not occur, as under our conditions? Probably, we would have to be even more cautious in using words" [18a, p 136].

In conducting social psychological research at the hydrometeorological stations under the conditions of the Far North, I. K. Keleynikov has established that the new members of a collective usually attract particular attention, but in time interest in them flags.

In all the above-given descriptions, people had an opportunity to obtain information from books, magazines and the radio. "We never broke off contact with the civilized world," wrote R. Byrd, "and news both good and sad flew to us, crossing the vast expanses of the southern ocean and the ice fields.... On those evenings when the radiomen were unable to get the last news, spirits were down in Little America. The daily news transmitted over the radio of the NEW YORK TIMES was received by our radio operator, and each evening was put up on the information board. Thus, we were more or less abreast of all world affairs and we always had subjects for new discussions" [26, p 259].

Information exhaustion of persons in group isolation is felt particularly acutely and rapidly when they are deprived of sources for replenishing their own knowledge and impressions through one or another channel of information. An example of this would be the winter spent by Nansen and Johansen in a small hut on Franz Josef Land in 1895-1896. In a chapter of his book entitled "In the Winter's Den," F. Nansen writes: "Entries in the diary at that time were extremely sparse. Sometimes entire weeks passed and nothing was written in the diary, except the required meteorological observations and numerical data. Life was so monotonous that there was nothing to write about. Day in and day out the same thoughts came and went. There was no more diversity in them than in our talks. The very emptiness of the diary gives a full understanding of our life during these 9 months of our winter.... A strange way of life to lie for the entire winter in a hut, almost underground, without anything to do and nothing to undertake decisively. How we would have liked just one book!... All subjects of conversation had long since been exhausted. There remained virtually no thoughts of any common interest which we had not already exchanged" [157, pp 274, 288].

Thus this information exhaustion of the partners living together as well as the constant "publicness" (we will take it up in more detail below) lead to a situation where the people begin to tolerate one another with difficulty. We have already written how Nansen responded to this state in the lecture "What We Do not Write About in Books." Jack London in one of his tales wrote about two gold prospectors forced to remain for a winter in a small hut. They actually destroyed one another.

What are the measures which have developed spontaneously under expeditionary conditions and aimed at mobilizing all the information reserves of a man?

One such measure, judging from the reports of polar researchers, is the organizing of popular lectures given by specialists from the expedition. Thus, Borchgrevink writes that during the antarctic winter "reports were given on polar, literary, religious and political subjects.... Here, the main thing was achieved: drowsing thought was aroused to new activity" [23, p 107].

"During the winter months," R. Byrd has written, "twice a week professors and docents from the antarctic university gave lectures on various subjects relating in one way or another to the scientific research goals. Dr Gould gave a course on geology which he had given at Michigan University. His lectures were attended by virtually the entire winter party. Mason and Hanson gave reports on radiological science; June with the help of Balken and Smith conducted a group on aviation, while McKinley spoke on aerial surveying. These exercises, in introducing a useful and at the same time pleasant diversity into our lives, were supported in every possible way by us. Due to them, the members of the party acquired a correct notion of tasks of the expedition and learned a great deal" [26, pp 258-259].

"In order to inject some diversity into our life," wrote Mario Mare, "and to become more familiar with the professions of one another, in the evenings we organized a sort of scientific conference. Rivolier acquainted us with biophysiological terminology, and Preveau with embryology. I told the friends something about electronics" [148, p 88].

P. D. Astapenko has written that "in Little America 5, lectures were often given on the most diverse subjects. Usually they were accompanied by the showing of slides.... For those so desiring, more than 10 groups were set up including language, technical, and general educational" [10, pp 51-52].

We feel that a portion of the theoretical preparation of the cosmonauts can be shifted to the interplanetary flight. According to a previously worked out program, the specialists of the crew will be able to give series of lectures which not only enrich each member of the expedition, which in and of itself is important, but will also provide food for various discussions.

Judging from the reports of the polar researchers, the conducting of such discussions has served as a means for combating the isolation of the people caused by a decline of interest in one another. However, in organizing the discussions, as in conducting various sports tournaments, the commander of the ship will have to consider the psychological state of the crew members at a specific moment. "Arguments and discussions," wrote R. Byrd, "are both the joy and grief of the polar night. How ardently they flared up at Little America like a fire consuming a dry tree.... Initially there was a sincere and harmless conversation which quickly drew into a passionate discussion which became more and more heated until it threatened to turn all of us into a heap of ashes...." [26, pp 247-248].

R. Amundsen has felt that in order to prevent the isolation of people, it is essential to keep them as far apart as possible during working hours. "In meeting at the end of work," he wrote, "they will always find something to talk about" [6, p 159]. This notion of the scientist helps us move on to examining another extremal factor, that is, the constant observance of each member of the expedition by its other members.

"Publicness" as an Extremal Factor of Group Isolation

> One of the greatest tortures is not to be able to be alone, and to eternally be watched....
>
> S. S. Korsakov

We can gain some notion of the importance of this factor having analyzed the decision of R. Byrd to spend a winter during his second expedition to Antarctica on the Ross Ice Shelf alone, although there was an opportunity to take someone as a "mate." He justified this decision in the following manner: "In being guided by experience and in knowing the specific conditions of life in the polar areas and their effect on the human psyche, after long reflection I concluded that it would be most unreasonable for two persons to stay at the station during the winter. Certainly it must not be forgotten that this meteorological outpost was in the interior of the Ross Shelf, and its inhabitants would have to remain completely alone for at least 7 months, while four of them would be spent in absolute darkness under the most unfavorable conditions which one can imagine in the world. Life at the station in many regards was reminiscent of life on a dark, dead, frozen planet, and for long weeks the station would be just as unreachable as a distant planet. And then two men should take shelter in this icy grave at the end of the world, in the oppressive polar night, with the dull light of a flashlight, in the darkness and discomfort. No matter what their mood or mental state, they would eternally be in each other's view, for there was nowhere for them to go. Each superfluous step, each gesture or each casually said word by one could cause infinite irritation for the second, because any trifle assumes monstrous importance. What nerves could sustain such constant tension? Under such conditions would it be possible to anticipate the reaction of one's best friend or be completely confident in one's own state and perception? Certainly, it is not to be excluded that two persons could achieve complete spiritual harmony in such cohabitation. There is nothing impossible in the world, in particular, when it is a question of the human psyche. But still I personally preferred complete solitude to the danger of beginning to hate my comrade or becoming hateful to him" [27, pp 129-130].

In reaching such a conclusion, R. Byrd had every justification: "During the first winter at Little America," he wrote, "I spent many hours with a man who was on the verge of murder or suicide because of an imagined persecution by another man who previously had been his true friend. No one is completely protected against this" [195, p 240].

However, he had miscalculated. Life alone in a small hut, surrounded by the silent snows during the polar night, became a nightmarish existence for him.

After 3 months of solitude, Byrd judged his state as depressive. He began to fear carbon monoxide poisoning from the stove inside, he feared the collapse of the roof under the snow, and that he would not be promptly rescued. Later on, the apathy had such an effect on him that he ceased being concerned about eating, about maintaining warmth and his personal hygiene. He lay in bed without any desires, and he began to halluzinate.

In this regard, of great interest is the evaluation given by A. G. Nikolayev of a single and group flight. To the question of journalists as to what new sensations the cosmonaut experienced during the second flight, he replied: "The general sensations during this flight were approximately the same as during the first, and there was nothing particularly unusual. Of course, on the 'Vostok' it was boring to be alone in the cockpit, but here there were two of us. It is always better to work with a comrade. There is someone to seek advice from, you feel your comrade near and are aware that in a difficult moment he can always come to your aid" [160, p 85].

In jumping ahead somewhat we can say with complete conviction that with a correct approach to making up the group, and in considering the patterns operating in it, a person could live an unlimited time without harm to his mental health, while extremely long solitude, as a rule, leads to the development of a mental illness. However, this conclusion does not obviate the fact that the constant observation by others does cause an onerous state.

Experimental research also shows that this is so. We have already said that with television and other devices under the conditions of an isolation chamber, the subjects are under constant observation. The state of the subjects under constant observation has been termed "the publicness of solitude" in the work of O. N. Kuznetsov [98]. One of the female subjects, N., in her final report after the experiment, said: "I was most bothered not by the solitude as I am accustomed to it and like it, but rather by the fact that I was being watched."

A characteristic entry from the diary of a physician-subject: "Excessive control from the other side goes simply beyond the limits of decency, as they have turned on a tape recorder. They listen and write. They note everything and overhear everything. And all of this is somehow unpleasant and rubs one the wrong way" [107, p 153].

How can the psychological mechanisms of this phenomenon be explained? According to the theory of the "social roles of the personality," in the behavior of people there is always something set by society, by its standards, prohibitions and traditions. In performing one or another functional role, a person becomes to a certain degree "an actor on the great stage of life." Thus, the leader in the eyes of his subordinates involuntarily behaves differently than in a home situation. There are many behavior actions which a person scarcely will permit himself to perform in the presence of others. The numerous documentary films taken by a "candid camera" also show how people behave differently in society and alone.

When a person knows that he is being watched, he endeavors to constantly maintain a certain role function, and conceal from the others everything that possesses him at the moment. In experiments involving extended isolation under the conditions of an isolation chamber, one can see unique pictures of behavior by various subjects, and in particular, women. Female subject A. was reticent, and in comparison with her ordinary behavior she showed inhibition and economic movements which were strictly necessary for the activity performed. In the apt expression of one of the observers, the subject "rolled herself up in a ball," in desiring to conceal her internal world from the intrusive view of the experimenter.

Female subject B. had a constant curious, standard, somewhat emotionally indifferent and unexpressive smile. Her movements and gestures looked like they had been thought out and were intentionally refined which is unnatural for unobserved solitude. The subject "was playing up to the experimenter." Female subject G. during the experiment was excessively busy and artificially gay. Her spontaneity was somewhat unnatural.

Such a "game" for the viewer causes constant strain on the nervous system (and this causes depressive experiences) and cannot be sustained indefinitely. R. Byrd writes the following about this process under the conditions of group isolation: "People can work together in full harmony in sunlight when labor absorbs their energy, and the conditions of life make it possible to separate if some random factor causes their nervous irritation. Under such conditions, an intelligent and self-controlled person can conceal his true feelings and even his inner being. In this regard, he is helped by the circumstance that his comrades have neither the time nor the desire to penetrate his inner world. But the situation is totally different in the polar night. There is nowhere to escape. All life is limited to the four walls, and everything that you do, say, or even think becomes known to all. Comrades constantly observe you, both openly and covertly, as there is so much leisure time! And when 40 different individuals lead a boring existence for long months, inevitably all sorts of clashes arise, not physical but rather of a psychological character. Here no one is fooled. Sooner or later the inner essence of a person should be disclosed, and only it alone plays a role, and only from it a person is judged. This inevitable process can turn a polar night into a hell for certain types of people" [26, p 233].,

A. N. Bozhko writes about the factor of constant publicness: "We do not have an organic dislike for one another, but at times it is difficult to surmount the extreme subjectivism in oneself for the sake of the common good. How difficult it is at times to look calmly into the eyes of someone else. And we still have many months more to sit at the same table, to breathe the same air and be in the very limited quarters. There is nowhere to go" [18a, p 37].

"Researchers are unanimous in the opinion," pointed out V. V. Boriskin and S. B. Slevich, "that the basic factor determining the emotional responses of individuals and the collective as a whole is the limiting of life to the confines of the station. Precisely this factor and not the cold climate, not the difficulties of the work or the hard living determine the psychological adaptation of the members of the party. A person, in being constantly in the company of the same people, is forced to strictly control his emotions. And the fewer persons there are at the station, the greater the psychological stress.... In isolation under severe natural conditions, both the poor and the good character traits are clearly evidenced. Dissatisfaction which develops in one can spread rapidly to the entire expedition" [21, pp 31, 34].

This "hell," in the expression of R. Byrd, for certain categories of people terminates in the development of reactive psychoses which have been termed by the polar researchers "expedition madness." Thus, according to the data of P. Law [145], in 1959, six mentally ill persons were evacuated from the American antarctic stations. He writes that mental illnesses also arose at the Australian antarctic station. Of course, it is not any one factor, for example, living together, but rather a complex of them which is to blame in the development of psychoses under expeditionary conditions. However, in and of itself, the factor of constant "publicness" for a person can serve as the cause for the development of a reactive psychosis, and this is substantiated by the following observation.

As was already pointed out above, during an extended isolation chamber experiment, female subject N. found burdensome not so much the state of isolation and solitude but rather the fact that she was constantly being watched. This notion did not leave her not only in the unscheduled time, but also accompanied her, like a constant companion, during the period of performing the work provided by the program. The subject related that she constantly watched herself and was afraid of "appearing indecent." At the end of the experiment, it even seemed to her that the observers in the control room could read her thoughts from her face, eyes, gestures, or from any small movements, "that she was completely exposed," and that her thoughts could be read from the electroencephalographic recordings. This state of "exposure" was extremely burdensome for her. The subject assessed her feelings as if not morbid, in any event unusual and unpleasant. She unsuccessfully tried to counter them, and after emerging from the isolation chamber for some time felt awkward with the coworkers who conducted the experiment. The thought that they knew more about her than she wished did not leave her. Only after 10-12 days did she return to normal. Such a state must be viewed, evidently, not as a developing neuropsychic illness, but rather as a borderline or transitional phase from health to sickness.

Judging from the data in the literature, in certain instances the participants of expeditions who live in group isolation after a certain time cease feeling shy with one another. In comparing the voyages on the "Ra-1" and "Ra-2," Yu. A. Senkevich writes that during the second voyage it was discovered "that we had ceased being shy with one another. We walked around, figuratively speaking, in our negligee, we did not fear touching the other person in word or by gesture, and the frankness of our replies was at times excessive and bordered on the impolite" [185, p 134]. In other instances, there is a complete disclosure of one's spiritual world to one another.

In the preceding chapter of this book, we quoted the mutual evaluation of two persons in the diary entries of Quentin Reilly and Martin Lindsay during a winter on the Glacier Shield in Greenland. In recalling this winter subsequently, M. Lindsay wrote: "And although the days spent together on the Glacier Shield broke down any obstacles between us, as strange as it seems, such closeness has never been recaptured" [189, p 17]. In commenting on this entry, Scott, the leader of the expedition, wrote: "When you look back, this does not seem at all strange. Regardless of how their temperaments differed in other regards, they both belonged to that type of person ready to make voluntary sacrifices. (This reappeared during the war.) They followed the same inclination to do what they had to do. Under those primitive conditions, they looked at things in completely the same way, and this is never observed among two persons, no matter how much they have in common, in an ordinary full life at home. If they merely returned to the Glacier Shield, without any effort they would again be captivated by those same interests, in amusing each other with reminiscences about their life at home and talking about themselves as if strangers from another world" [189, pp 17-18].

Such harmony in relations for a long time, in all probability, can be achieved between two and possibly three persons, while the crew of the ship will consist of 7-10 persons.

In order to make "life more endurable" for 7-10 persons living under the conditions of group isolation in expeditionary conditions, Mario Mare feels that in building the quarters for polar winters, it is essential to provide "that each member of the expedition have a separate even small room. This condition is essential for the moral health of the inhabitants...." [148, p 59]. And here is what C. Borchgrevink writes who as a member of a 10-man expedition spent a winter in Antarctica in 1889-1890: "The wooden bunks were placed along the walls one above the other. Upon the advice of the physician, the bunks were closed off by partitions so that we had to crawl in and out of them through an opening covered by a piece of material. The doctor felt that for many it was beneficial and even essential at times to be alone; the correctness of this was soon substantiated. When we lay there cut off from the entire world on our bunks, the latter, in terms of their comfort and appointments could, of course, seem like a modernized coffin to us. But such an arrangement was very useful in practice. During the arctic night we so got on each other's nerves that at times the following picture could be observed: someone, in intending to crawl out, would carefully lift his curtain to make certain that there was no disliked person in the room. Seeing a comrade who had already gotten out of his bunk to gulp fresh air, he relowered his curtain as if he had seen the severed head of the Medusa" [23, p 70]. In the year-long isolation chamber experiment, every 10 days the subjects changed their sleeping bunks located one above the other like in a railway car. A. N. Bozhko wrote that each person impatiently waited his turn to get the upper berth since it "provided maximum privacy" [18a, p 128].

On the need of the members of the expedition for privacy, we find the following written by R. Byrd: "There were several of our men who, regardless of the cold, each day went out for a walk. Sometimes we went in groups, but more often walked alone,... because each person wanted to be alone with himself. Several minutes of solitude and contemplation under the high vault of the heavens had a very beneficial effect" [26, pp 263-264]. "We rejoiced over the fall of night," said A. Bren, "for when night fell, we did not see one another" [61, p 137].

All of the given materials, in our opinion, eloquently show that on an interplanetary ship, there must be separate cabins for one or two persons.

In concluding the chapter, we would like to take up psychological training which, along with the other preventive means, should be part of the instrumentorium for preventing psychic stress under the conditions of a long spaceflight. One condition for such training is an understanding of the mechanisms for the development of tension in relationships under the conditions of group isolation. Another is the ability or capability to prevent a conflict situation. The latter, in the opinion of B. S. Alyakrinskiy, can be achieved as a result of training. "The person training," he writes, "should be perfectly aware that an emotion which is the same in content can be caused by stimuli which are in different relations to it. Some such stimuli are outside the sphere of a person's effect on them, and they are completely independent of him" [5, pp 66-77].

Experience indicates that a person is most stimulated by what is most dependent upon him, and what he can affect most strongly. The least emotional are those stimuli which a person cannot control. For this reason, a person living in a group should learn mentally "to translate" stimuli from seemingly accessible to his influence into inaccessible ones. "Thus," writes B. S. Alyakrinskiy, "if the source of irritation is the particular features of the partner's speech, his slowness, or on the contrary, excessive mobility, it is essential to convince oneself that these personality traits of the partner are not intentional and do not depend upon him just as his height, hair color, and so forth do not. It is essential to be aware that my partner may find unpleasant some particular features inherent to me, and that, consequently, I have no right to condemn him or be dissatisfied with him. In this manner gradually a capability is evolved for objectivating the psychological makeup of one's comrades in the group and in this manner weakening the negative emotions caused by them" [5, p 77].

He goes on to point out that the person training should be "aimed" at showing "maximum vigilance" in regard to the negative emotions which arise in him. He should learn how to focus his awareness on an emotion which is formed somewhere on the periphery and related to the partner in the group. The author stresses that "even an insignificant rapidly disappearing irritation should not go unnoticed by each group member. It is essential to be aware that this passing feeling can grow into a strong, now poorly controlled emotion" [5, p 72]. Consequently, each of the members of the group should establish the cause of a negative emotion and suppress it. A unique method for releasing psychological tension in relations was found empirically by the testers in the year-long experiment. "We decided," wrote A. N. Bozhko, "with friction to discuss the subject of the argument frankly and calmly, and to get to the heart of it. Here one rule was observed: each person should speak of his own mistakes. Criticism of another person was prohibited. The results were excellent. We even coined the term 'recuperate relations'" [18a, p 92].

The keeping of diaries can be a "drain" for negative emotions under the conditions of group isolation. Substantiation of this could be the excerpts from the diary entries of two subjects between whom psychic tension arose in group isolation.

Gavrikov, 16th day: "Appetite has declined noticeably. Today I almost didn't sleep. It is easier for Petrovich. He at times works miracles. Yesterday he was extremely polite. Good fellow! It seems it is easier for him to change pace.... One-third of the experiment is already over. A small result can be summed up. The most difficult were the 5 days until we had become accustomed to one another, to the chamber, to the surroundings, until we became used to the idea that we had 45 days to go nowhere.

"I feel that the diary is becoming a consolation, and I feel like writing. Probably the limitation of contact is telling."

24th day. Kukishev: "On the 5th-6th day he so amazed me with his sighs, groaning, yawning, his too obvious, it seemed to me, apathy and intentional negativeness of judgments that it was very difficult not to give away one's state by a word, tone, gesture, behavior or attitude. The diary helped. If it were not for this channel where all the experiences of the moment could be poured, one careless phrase could become the cause of lethal consequences."

"Under such conditions," A. N. Bozhko writes, "when there is no possibility to 'pour out your soul,' the diary becomes the sole quiet friend and always faithful ally. Moreover, it makes it possible to look at yesterday's events from the position of today, and such analysis is always beneficial.... It is able to 'release' a charged situation, as well as help critically assess one's conduct and the conduct of comrades. It is a good means for suppressing irritation, and helps record interesting events of our life. Finally, work on a diary fills in free time, it does not allow idleness to develop which is the most terrible enemy under the conditions of isolation. For this reason day in and day out I keep a diary of the events of our life. German is doing the same thing and, probably, from the same considerations" [18, p 36].

Borchgrevink, Byrd and others have also written about the beneficial influence of diary entries of an intimate sort under the conditions of group isolation. It is also of interest that for many writers, the creative process has been a "liberation" from the feelings and experiences which have overwhelmed them. Of this state Lamartine has written: "Blessed is he who invented writing, this conversation of man with his own thought, this means for unburdening his soul. He has prevented more than one suicide" [9a, p 195]. Arnaudov in the same work quotes the following words of the writer Yavorov: "Suffering always disappeared from my soul, if I found the word to express it" [ibid., p 188]. Yavorov is echoed by the French writer Andre Gide who wrote that "if he had been impeded from creating books, he would have ended his life in suicide" [ibid., p 192].

B. S. Alyakrinskiy feels that a diary, as a means of getting rid of negative emotions justifies its purpose only "when its author gives predominant attention to his behavior in the group, his experiences in relation to the other members of the group, and when he examines all instances of a growing or already arisen conflict and the share of his blame in this both frankly and self-critically" [5, p 77]. It is of interest that, judging from the note of one of the persons who wintered in Greenland in the expedition of D. Scott, a diary provides an opportunity to be alone under the conditions of group isolation. "It is already a well-worn truth," writes D. Scott, "that emptiness has little in common with solitude. There we had much less of an opportunity for solitude than in ordinary life.... Solitude was for us only dreams or in a somewhat different form when we wrote our diaries" [189, p 84].

From all the materials given in this chapter, it follows that under the conditions of extended group isolation, psychological tension often arises in the relations between the members of the expedition. The latter is caused by the asthenization and other changes in higher nervous activity, as a result of the effect of an entire complex of extremal factors on man. This complex also includes such factors as "information exhaustion" of the group members and their constant "publicness." For preventing psychological tension during long spaceflights, it is essential to select people with high emotional stability and with well-developed volitional qualities and high intellect. On an interplanetary ship, a separate small room must be provided for each member, and preventive measures must be also elaborated for combating the effect of the extremal factors.

CHAPTER IV: PSYCHIC ACTIVITY UNDER THE CONDITION OF WEIGHTLESSNESS

All living beings which inhabit our planet have developed and are constantly under the effect of the earth's gravity. Its effect has been reflected not only in the size and shape of animals and in a number of physiological functions, but also in the psychophysiological mechanisms in the activity of the human brain.

Weightlessness is the most specific factor to which the human organism is exposed during a spaceflight. Prior to the start of spaceflights, many opinions were voiced over what effect the state of weightlessness could have on psychic activity. For example, the German scientist Trebst felt that under the effect of weightlessness, a person would completely lose the capacity for reasonable actions. Soviet scientists also did not exclude the possibility that unusual psychic states would appear during a spaceflight. In particular, this was reflected in the placing of "logical locks" on the first spacecraft. The essence of the work of these devices was as follows. In order to move from automatic control of the ship to manual, the cosmonaut had to select on a six-button board a certain three-digit number, and only after this could he switch to manual control. The cosmonaut would have to keep the "key" for this "logical lock" in his memory. In the opinion of specialists, in the event of the appearance of psychic disturb[illegible] person would be unable to handle this task.

If we go back to the history of the questic., we will see that [illegible] study of the effect of weightlessness in the Soviet Union started [illegible] placed in special containers of high-altitude rockets. Then the e[illegible] were shifted to man during flights on jet aircraft following the [illegible] parabola. And only after these experiments did manned flights in [illegible] commence, and in duration they were increased gradually from one orbit by Yu. A. Gagarin to a 30-day flight by A. A. Gubarev and G. M. Grechko on the Salyut-4 orbital station.

At present, extensive material has been accumulated on the effect of weightlessness on human psychic activity. Although weightlessness still entails much that is unknown, a number of generalizations can be made even with the present level of knowledge.

Activity of Cosmonauts Under Conditions of Weightlessness

> They experienced blessed quiet and silence. The position and direction of their bodies in the rocket was undetermined. It was whatever they wanted.
>
> K. E. Tsiolkovskiy

In light of modern physiological and psychological data, the ability of man to perceive the position of his own body relative to the plane of the earth and to perceive the position of objects of the external world in relation to one another and to man himself is not determined by the specific activity of any individual analyzer, but rather depends upon the joint work of many analyzers. For example, the reflection of the spatial position of the body relative to the earth's plane at each moment is achieved with the aid of the following analyzers: visual (optic), statokinetic (vestibular), proprioceptive (muscle-joint sensitivity), cuteomechanical (tactile sensitivity), and interceptive (sensory endings located in different internal organs, for example, the baroreceptors in the walls of vessels). Here, light energy is an adequate stimulus for the optic receptor, and mechanical energy for all the others.

Thus, the orientation of man in space under terrestrial conditions is carried out with the aid of a number of analyzers and those structures of the cerebral cortex which synthesize their activity into a single process of the reflection of spatial relationships.

Long before spaceflights, on the basis of theoretical arguments, scientists asserted that under the conditions of weightlessness the load would be removed from the muscles constantly working under the conditions of gravity to support the vertical position of the human body (stance). These arguments were affirmed in observations during flights on jet aircraft which briefly reproduced weightlessness. Ye. M. Yuganov and others [228] disclosed that the amplitude of the biopotentials in the neck muscles equal to 130-180 microvolts in a horizontal flight, under the conditions of weightlessness drops sharply (to 40-50 microvolts). Analogous changes were also observed in the bioelectrical activity of the hip extensors and flexors. While in the initial state the amplitude of the biopotentials equaled 30-37 microvolts, in a state of weightlessness, bioelectrical "silence" was observed.

Subjectively, the deactivating of the stance musculature was perceived by many cosmonauts as a unique lightness. The cosmonaut Ye. V. Khrunov has described this state during a spaceflight: "I cannot compare weightlessness with any other terrestrial sensation. Weightlessness is an unusual feeling of lightness throughout the body." The American astronaut A. Shepard assessed this state as "bliss--no more no less." "But it must be pointed out," noted the cosmonaut G. T. Beregovoy, "that this present lightness or the sensation that you have dissolved in the atmosphere surrounding you is good only initially, at first. Later on the body begins to grieve for loads. We are accustomed to them, so to speak, chronically, from birth. By the end of the first day I suddenly had a great wish to feel myself, to sense myself from the inside, with muscle fibers and joint ligaments; I wanted to bounce, to crouch down, to stretch until my bones cracked" [13, pp 203-204].

In some cosmonauts, unique illusions have occurred at the moment of moving from acceleration to weightlessness. Thus, at the moment the spaceship Vostok-2 entered orbit, G. S. Titov had the illusion that his body was turning upside down. The American astronaut G. Cooper experienced analogous false sensations.

Figure 3. Cosmonauts G. T. Dobrovol'skiy and V. N. Volkov on the Salyut Orbital Station

Here is how V. N. Volkov describes the occurrence of the illusion when the Soyuz-7 spacecraft entered orbit: "The third stage ceased firing very smoothly. So gently that we did not even notice when this occurred.... It seemed that I was hanging head down, and the horizon of the earth which I could see through the window was floating somewhere beneath me. I was not the only one to have such an illusion. Anatoliy and Viktor also experienced a similar feeling. It lasted literally seconds" [30, p 111]. Other cosmonauts also experienced the illusion of turning over upon entering weightlessness.

F. D. Gorbov has linked these illusions with the continuation of a muscular reaction of support under new conditions. During the moment preceding weightlessness, the forces of acceleration push a person into the seat, and a muscle counterresistance is created to the back of the chair. And if in moving to weightlessness, the contracting of these muscles is not weakened, then a natural but at the same time false impression occurs that one is flying on one's back or upside down. With an even muscular relaxation, such a notion would not occur.

It is essential to point out that illusions have also appeared in some cosmonauts after the ship had entered orbit. For example, in the course of an orbital flight, the cosmonauts B. B. Yegorov and K. P. Feoktistov experienced illusory sensations. To one of them it seemed that he was half bent over with his head down, and to the other it seemed that he had turned upside down. The cosmonauts noted that they had these illusions both with their eyes closed and eyes open. During their 14-day flight, the American astronauts Borman and Lovell (4-18 September 1965) had illusory sensations of an upside down position for the first 24 hours.

Long before spaceflights, K. E. Tsiolkovskiy assumed that under the conditions of weightlessness, a person might have spatial illusions. However, he felt that it was possible to adapt even to such unusual conditions. "All these illusions, at least in the quarters, should disappear over time," wrote Tsiolkovskiy [135, p 80]. And this prediction of the theoretician of cosmonautics was proven out in practice. "During the first minutes I closed my eyes," wrote G. T. Beregovoy, "I leaned my head against the back of the seat, and immediately the sensation arose that I was turning over ever so slowly, as if I were doing a back-flip. I was wondering if I would make a complete turn of 360 degrees. But as soon as I opened my eyes, the illusion of rotating disappeared. I could see that I was sitting still in the seat, and was even firmly strapped in. Incidentally, about 2 hours later, all of this was gone. Moreover, by this time I had already unstrapped myself and moved freely throughout the cabin. And the specific sensation had gone which arose initially with an abrupt turn, when for a split second it seemed as if there was no ground under your feet. And, in fact, there was none. At one minute your feet could be on the wall or then on the ceiling. But the feeling of the absence of ground under your feet was perceived in a purely terrestrial manner. It was approximately as if a stool had suddenly slipped from under your feet. But this, I repeat, also passed, you could turn as you wished. And the longer you went the better it was. About 5 hours later, when I had more or less firmly mastered the skills of moving about purposefully, I decided that a constant, stable state of weightlessness was a very pleasant thing. Neither nausea nor dizziness, only an unusual lightness throughout my body. You could swim through the air wherever you wished, and the wish was reinforced by the principle of jet efficiency. For example, you spread your arms apart and your head and body move forward and down into a straight flip; and, on the contrary, bring them together and you are lifted into a back-flip and even further. Repeatedly I recalled our training in the weightlessness 'tank' and this was very useful" [13, pp 203-204].

The essence of occurrence of illusions, in all probability, can be explained by the following physiological mechanism. Since the blood has an intrinsic weight, its pressure under the conditions of terrestrial gravity in the lower areas of the body is greater than in the upper ones. Thus, in an

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upright position, the large veins in the lower parts of the body are subjected to a pressure of around 100 mm Hg. Due to the fact that the hydrostatic "column" of the blood under the conditions of weightlessness loses its weight, there is an even redistribution of blood pressure through all parts of the body. And since the vessels of the brain under ordinary terrestrial conditions are not adapted to a change in pressure, this redistribution gives rise to the above-described illusions. "The physical sensation," related V. A. Shatalov at a press conference after his first flight, "is as if the blood were constantly flowing toward your head, as if you were constantly floating somewhere. You lose the sensation of up and down. And it seems that you must constantly hold on to something not to float. You hang, holding on to something, you reach out, and then it turns out that you are hanging in midair with no place to fall. But these sensations were only in the first period, before the organism had adapted to weightlessness" [222, p 132].

G. T. Dobrovol'skiy, after the Soyuz-2 transport ship had entered orbit, in his diary on 6 June 1971, thus described his state: "After the separation, the sensation of discomfort consisted in a feeling as if someone were trying to pull your head off your neck. You could feel a tensing of the the chin muscles, a heaviness of the head in the upper portion and the occiput, and it seemed that your innards were stretched behind the head. When the body was strapped in the seat, this phenomenon diminished but did not disappear. In any event, the frontal and occipital portions of the head felt heavy. Your stomach was being drawn upward. One became immediately accustomed to moving one's arms, to the sensation of everything with which you had to work, and to the dynamics of your entire body" [63, p 13].

Other cosmonauts have also experienced a sensation of rushing of blood to the head at the start of the flight. They compared this state with the sensations of an untrained person who was upside down on the earth. The rush of blood into the upper portion of the trunk was felt not only subjectively, but was also objectively apparent in the intumescence of the integument and mucuous membranes of the face.

This phenomenon was described by G. T. Dobrovol'skiy in his diary as follows: "Vadim and I looked in the mirror, and we laughed at each other as we had 'jowls' like a bulldog" [63, p 19].

One of the basic analyzers which reflects the position of the body relative to the earth's plane is the vestibular analyzer. It is a single system consisting of a peripheral receiving device, conducting nerves, a central portion with nuclei in the stem portion of the brain and an area of cells in the cortex of the hemispheres. The receiving device, in turn, is divided into the semicircular canals and the otolith apparatus located in the temporal bone. Three semicircular canals are located in three reciprocally perpendicular planes and are filled with a fluid called endolymph. At the start of each canal there are "brushes" of sensitive endings of the vestibular nerve.

In 1878, the well-known St. Petersburg physiologist Ye. P. Tsion, for the first time explaining the significance of the semicircular canals in forming notions of space, wrote that the semicircular canals are the peripheral organs of spatial sense; in other words, the sensations caused by the stimulating of the nerve endings in the ampullae serve for forming our notions of the three dimensions of space. The otolith apparatus is, in essence, a gravity receptor which is adapted for sending information to the brain with a change in the force of gravity. The principle of action for this sense organ is rather simple. The bottom of a small sac is covered with sensitive nerve cells supplied with hairs and on which in a jelly-like fluid lie small crystals of calcium salts, the otoliths. Under the effect of the force of gravity, they press on the endings of the sensitive cells. The force of this pressure also changes with a rapid ascent or descent. The sensations arising thereby are well known to persons who use high-speed elevators.

In relying on the general theoretical notions of the loss of the weightiness of the body during a spaceflight, K. E. Tsiolkovkiy assumed that the state of weightlessness should lead to a change in the perception of surrounding space. In 1911, he wrote: "In a rocket there is neither up nor down per se, because there is no relative gravity, and the body left without support will not move to any wall of the rocket, but subjective sensations of up and down will still remain. We feel up and down, only their places change with a change in the direction of our body in space. We see up in the direction where our head is, and down where the feet are" [135, p 92].

This idea was substantiated by the observation of A. G. Nikolayev during a flight on the Soyuz-9 ship. "When we were eating in the ship," he wrote, "you could be in any position: with your feet up or down. I, for example, always like to put my feet on the ceiling, while Vitaliy sat on the couch with his feet on the floor, holding himself in with special straps. Our faces were on the same level, and we looked each other right in the eye. And, respectively, our faces were turned 180 degrees relative to one another. But such a position in no way impeded eating, we became accustomed to this and ate quietly, while during breaks we chatted, smiled and laughed. On the earth this would have appeared merely strange, but in weightlessness it is quite natural" [160, p 103].

"Still," wrote V. N. Volkov in his diary during a flight on the Salyut orbital station, "no matter how long a person has flown, he remains a terrestrial being. Regardless of weightlessness, this indifferent positioning of the body, a person still endeavors to assume a stance as if there was a floor under him" [30, p 189].

In a state of weightlessness, in a majority of the cosmonauts, a psychological notion arose of "up" and "down" as developed during training on a training spacecraft, although in fact neither "up" nor "down" any longer existed. "If you went into the orbital compartment," said A. S. Yeliseyev after the flight, it seemed as if no one was in there, but if you looked again, there was Khrunov sitting on the ceiling writing something, and in the most different poses--head up or head down" [64, p 132].

In a majority of the cosmonauts, a psychological notion of "up" and "down" corresponding to the geometry of the ship's cabin with eyes open was disrupted only in the instance when they saw the heavens "down" and the surface of our planet "up" in the window. This pattern was tested out in the following experiment. In a laboratory aircraft, on the wall, they attached a runner of special fabric on which it was possible to walk in a state of weightlessress. In walking over it in a state of weightlessness, the impression was rapidly created that this was not a wall, but rather the floor and that "down" was under your feet. But you have merely to look through the aircraft window and see the earth running parallel to the body and such an impression was quickly dispelled. Thus, in orienting the ship in an orbital flight, the cosmonaut should have a clear notion of what position the ship holds relative to the horizon of the earth and in what direction the craft is moving. Having realized all of this and having included the ship in the "system of the body," he begins to execute the maneuver.

On orienting the spacecraft during a flight, V. F. Bykovskiy has stated: "After activating the manual attitude control, I began to look for the earth. I looked through the window and through the 'sight.' Off to the side of the 'sight' I saw a corner of the horizon. I quickly realized that the right window was up, at the top. I moved the controls to the right and released them before the indicator went on. The opposite indicator did not go on. Immediately the movement of the ship was noticeable. The ship was moving forward at remaining velocity. I thought: 'Good, how economic this will be,' and began to wait. The movement of the earth was scarcely noticeable. Thus, I worked for all three axes at remaining velocity.... What was interesting in this orientation was that the ship obeyed the controls excellently. I even rejoiced over how well everything turned out. In determining the run of the earth from the 'sight,' I oriented the ship 'for a landing'" [40, p 69].

During an orbital flight, the cosmonauts may become "seasick." Thus, G. S. Titov had unpleasant sensations which were characterized by him as a state close to seasickness, and were expressed in dizziness and nausea. When the cosmonaut turned his head sharply, the dizziness was intensified and the illusion appeared of "floating" objects. The cosmonaut noted that not only the turning of the head but also the glimpsing of objects ("the run of the earth") caused unpleasant sensations. The designated phenomena were reduced when the cosmonaut assumed a comfortable stance and ceased moving his head sharply. After sleeping, these sensations lessened, and completely disappeared after activating the ship's braking system. Regardless of the signs of motion sickness, the cosmonaut was able to continue working.

Generally speaking, with brief weightlessness, as well as in the period of adapting to its protracted effect, people show a broad range of responses caused by individual differences. Thus, in particular, for the third crew of Skylab consisting of the astronauts Carr, Gibson and Pogue, during the first days the program ran a bit behind schedule. They all had slight headaches, symptoms typical, according to statements from the flight controllers, for all astronauts during the first days of the flight.

In the work "Ukachivaniye kak Problema Kosmicheskoy Meditsiny" (Motion Sickness as a Problem of Space Medicine), G. L. Komendantov and V. I. Kopanev have written that "the state of higher nervous activity is of great importance in the genesis of motion sickness. In persons of the strong type, motion sickness is observed more rarely, and in the event it does appear, it occurs more mildly; the opposite is observed in persons with a weak type of nervous system" [90, p 333].

Persons with a strong type of nervous system are selected as cosmonauts. But here, attention must be drawn to the fact that even among persons with a strong nervous system and for whom vestibular stimuli are professionally common, in the instances of asthenization or the exhaustion of the nervous system, severe disturbances of higher nervous activity may arise.

The conquering of space has posed new tasks for man during the flights. We have already said that long-existing orbital stations and interplanetary ships are to be assembled in orbit. The carrying out of assembly and electric welding work in putting these structures together requires that the specialists go out into open space. The cosmonauts must also go into open space for preventive inspection and repair of ship equipment during an interplanetary flight. Here, above all, the people must be able to orient themselves in open space.

If we return to the history of this question, we will see that the studies of the possibilities of orientation in unsupported space began in the "swimming pool" during flights of a laboratory airplane with the creation of brief weightlessness.

The cosmonauts were given the mission of comparing their subjective notions of the geometry of the "pool" with the real situation in moving in the "weightlessness pool" for a certain period of time (5-10 seconds) with their eyes closed. The experiment showed that during the first 2-3 seconds of moving with their eyes closed, the subjects, in considering the speed of movement and the sensation of their own rotation, were still able to recognize what was happening, in truth, at times with great mistakes. Subsequently, this was difficult for them to do. Thus, A. G. Nikolayev wrote in the report on the corresponding experiment: "After the start of moving and closing my eyes during the first 'hump,' I judged during weightlessness my position in space by memory. Here I felt that in addition to moving along the 'pool,' I was also turning to the right. According to my conception, I should have been approximately in the middle of the 'pool,' and turned 75-90 degrees. But when I opened my eyes, I saw that in fact I was along the right side of the aircraft and turned by 180 degrees, that is, I was facing the ceiling.

"During the second 'hump,' I did not open my eyes for approximately 10 seconds. After 4-6 seconds, I was unable to imagine my position in the 'pool.' I had lost my orientation. When I opened my eyes, I was in the tail of the aircraft 'hanging' upside down" [135, pp 98-99].

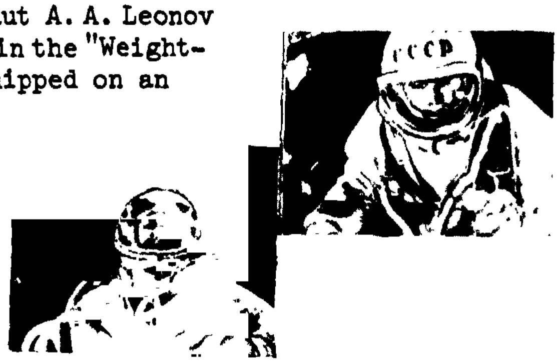
In exactly the same way it was difficult to determine body spatial position during orbital flights with eyes closed. "An interesting phenomenon," wrote V. N. Volkov in his diary, "related to assessing the body's spatial position in free gliding with closed eyes. In the first place, the assessment of one's movement differs greatly from what actually occurs. Zhora (Dobrovol'skiy, authors) and I conducted the following experiment. I closed my eyes and was still, lowering my arms and freeing my feet from the straps. I described my floating and subjective position, and this caused great amusement from the commander. Usually everything was quite the reverse" [30, pp 189-190].

Being in unsupported space in the "swimming pool" of the laboratory aircraft or in a spacecraft, a person has an opportunity by using his sight to compare the position of his body in space in relation to these areas. But in going out of the spacecraft, he encounters not only an unsupported state, but also "unoriented" space. The link between the cosmonaut and the ship is provided by a flexible lifeline. In this instance, there are no longer any tactile and muscle-and-joint sensations which arise from being in contact with individual parts and areas of support in the cabin. In open space, the nerve impulses running from the muscles and joints and the receptors of the skin do not make it possible to form any notion of the spatial relationships of the cosmonaut's body to the objects surrounding him, and provide only information on the relationships between the individual parts of the body, that is, of the "body scheme" which also includes the pressure suit and the lifeline. Consequently, in leaving the ship, the person's psychological notion of his position relative to the cabin based upon visual, tactile and muscle sensations is "destroyed," and he must move to a completely new orientation, "relying" solely on visual perception in a new system of coordinates.

In preparing a person for the first spacewalk, a system of coordinates was recommended in which the ship with its longitudinal and transverse axes was used as one of the "reference" points. In this system, the ship was "down." Such a concept was "hashed out" in the period for preparing for the flight. Several scores of diagrams were sketched out on which all sorts of variations were worked out for the position of the cosmonaut in free space relative to the ship, the sun and the earth.

Let us give the impressions of A. A. Leonov on his walk in "empty" space: "It was necessary to move around the ship flying at a cosmic velocity above the spinning earth. Movements away from the spaceship were executed on one's back, and movements toward with one's head facing frontward with arms extended to prevent striking the helmet visor on the ship or 'spread-eagling' over the ship, as in a free fall parachute jump on the earth. In moving, I oriented myself in space to the moving ship and the 'standing' sun which was over my head and behind me. In one of the movements away from the ship, as a result of the inaccurate shoving off from the spaceship, there was a complex twisting around the longitudinal and transverse axes of the body. Untwinkling stars began to swim in front of my eyes against the background of the dark purple infinite heavens which became velvet black. The view of the stars was replaced by the view of the earth and the sun. The sun was

Figure 4. Movie Frames of the Process of Cosmonaut A. A. Leonov Leaving the Hatch in the "Weightlessness Pool" Equipped on an Aircraft



very bright, and appeared to be driven into the blackness of the sky. Soon the angular velocity dropped due to the twisting of the lifeline. During the spin, when I could not see the ship, the notion of position was fully maintained and disorientation was not observed. In order to remember each moment where the ship was (when it was invisible), in my mind I had to trace back my route, considering at what angle I had moved away from the ship, and by how many degrees I had turned. The complex of psychological notions which provide orientation also included the reverse notion of the geometric relationships between the visible lights at a given moment (stars, the sun or the earth) and the invisible ship. The lifeline was also a good reference point when it was fully stretched out. It must be remembered that regardless of the numerous training sessions, there was no complete automation of coordination notions about space in which the ship was 'down.' However, the proposed method of orientation made it possible to execute all the missions set for me."

The American Gemini program continued the research started in the USSR on the possibilities of human activity in open space. The first American astronaut to go into open space was D. White. During the flight of Gemini-4, he made three sorties while the ship was flying over the illuminated side of the earth. White tested out a manual jet propulsion device which had three nozzles and which operated on compressed oxygen. Two nozzles with a thrust of 0.45 kg each moved the astronaut forward, and one with a thrust of 0.9 kg backward. In open space, this device was activated for just 3 minutes. Subsequently the astronaut moved about using the lifeline.

The mission of astronaut Cernan during the flight of Gemini-9 was to maneuver in open space using a backpack unit which could maintain the set body position in space automatically or be manually controlled.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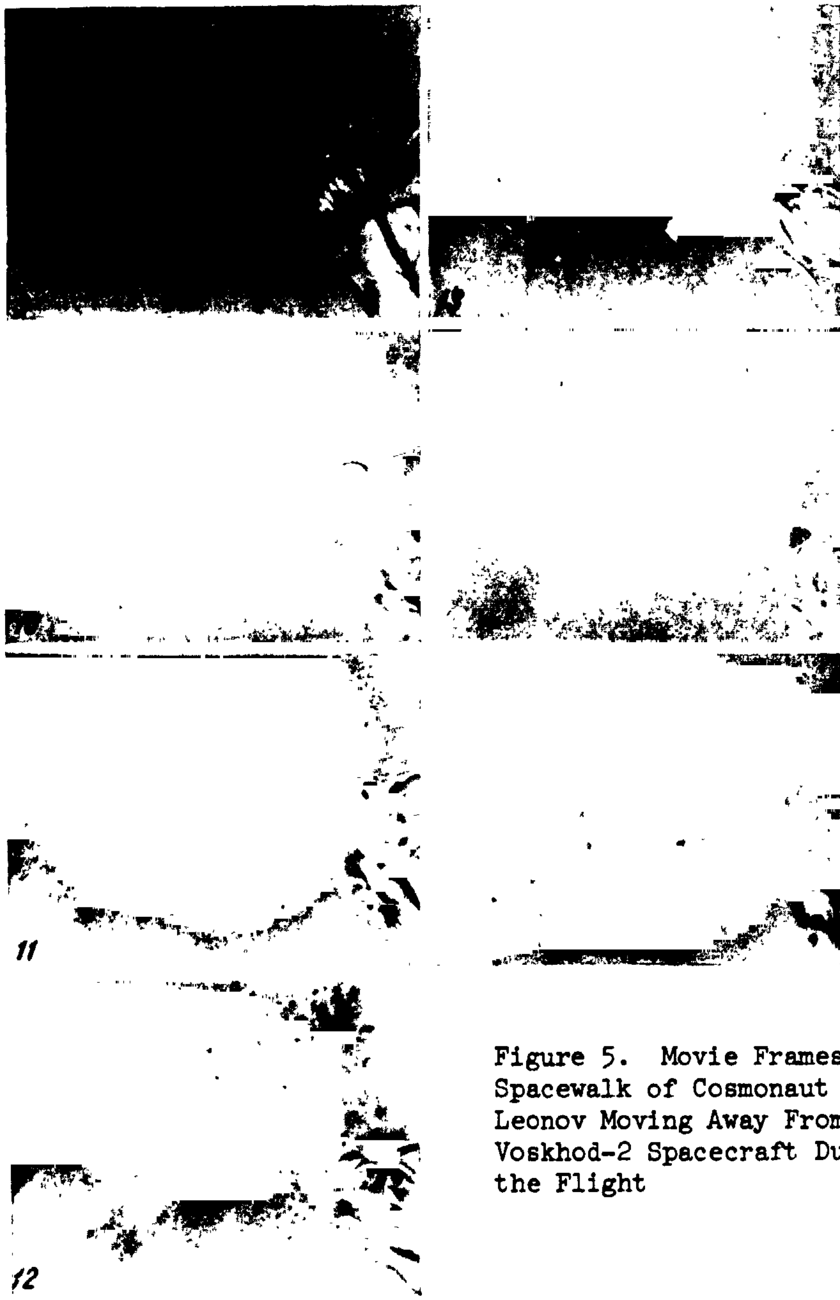

Figure 5. Movie Frames of the Spacewalk of Cosmonaut A. A. Leonov Moving Away From the Voskhod-2 Spacecraft During the Flight

These experiments must be viewed as the first steps in empty space. In future flights, when manned spaceflights will leave the earth for other planets, and the cosmonauts using jet devices will move farther and farther away from their ships into empty space, more complicated problems will arise on forming spatial concepts in the new "reference" system of coordinates. Under these conditions, it is essential to have not one but two or more systems of coordinate concepts with different "reference" points, and this will pose significant difficulties for the cosmonauts, since research indicates that "switching" from one system of coordinate concepts to another is psychologically a difficult task.

Thus, the experience of the orbital flights and the spacewalks of cosmonauts in empty space have shown that a man can adapt to orientation under such unusual conditions for him. Here, different relationships occur between the sensory organs than on the ground. Visual, tactile and muscular sensations are of chief importance, and responses from the vestibular apparatus less so. This functional system of analyzers is less stable in comparison with the natural one which was evolved during the extended evolutionary development of the organism. For this reason, a further study of the possibility of orientation during long spaceflights is an urgent task of space medicine and psychology.

Even before the start of the era of manned spaceflights, many scientists felt that the absence of the force of gravity should seriously alter the coordination of movements due to the disruption of the interaction between the visual, tactile and motor analyzers. In line with this, in preparation for the first spaceflights, the researchers were confronted with the problem of human motor activity. Experience showed that at first, unter the conditions of weightlessness, there was a slowing down in the execution of motor acts and a disruption of movement coordination with eyes closed. An extended stay under conditions of weightlessness was accompanied by an adaptation of coordination to these unusual conditions. Such adaptation is noted by the end of the first day and grows stronger during the subsequent days of the spaceflight.

During his first walk in empty space, A. A. Leonov, aside from moving about in empty space, assembled and disassembled a movie camera, and this showed the possibility of carrying out such operations on the exterior portion of a spacecraft.

Research on seeking out the possibilities for executing working operations in empty space in our nation was continued during the flights of the Soyuz-4 and Soyuz-5 ships. After the docking of these ships cosmonauts Ye. V. Khrunov and A. S. Yeliseyev executed a transfer from one ship to the other through empty space. In a press conference, Khrunov told in detail about carrying out the program of the flight mission. Here we will restrict ourselves to excerpts relating to the question under discussion by us.

"I left the ship easily," said Khrunov, "and looked around. The Soyuz-4 and Soyuz-5 ships were a great sight. The orbital station at this time was over South America. Having admired this striking picture of the gleaming spacecraft against the background of the earth and the black sky, I began to move around, and went up into the region of the docking assembly where on the Soyuz-5 spacecraft a movie camera had been set up on the outside in order to film the rendez-vous and docking of the spacecraft.

"I would like to clarify the concept of 'going up.' For us, in living on the earth, the concept of a transition or movement about is related, as a rule, with walking. But under the conditions of weightlessness, it is impossible to go over the surface of the ship in the usual sense of the word as there is no support under the feet and no force which holds man to the surface. Even on the ground, during training sessions, we found that it was easiest to move about in space and 'move' about in the ship from one place to another...on our hands, using the rigid handgrips. Thus, in gripping the handrails, I went up to the camera. In holding with one hand on to the rail, with the other I removed the camera from the bracket and unplugged its power supply from the side of the ship. Then, by the same method, 'on my hands,' I moved across the surface of the orbital station into the compartment of the Soyuz-4. In remaining half outside, I made observations of the earth's horizon, the work of the attitude control engines, I contacted the ship commanders and Aleksey Yeliseyev, I took a 'Salyut' camera from the orbital compartment and took several photographs of the ship.

"When we had entered the radiocommunications zone with the tracking stations of the USSR, I pulled toward me the camera taken from the bracket of the Soyuz-5 during the transfer and placed it on a special bracket by the hatch of the orbital compartment of Soyuz-4 and connected the power source. Now this camera would capture the emergence of Aleksey Yeliseyev and his transfer in space from Soyuz-4 to Soyuz-5.

"It should be said that it was not easy to execute the operations of removing and assembling the movie cameras under space conditions as well as take photographs with a manual camera. It was essential to be held in place where you were working" [214, pp 351-352].

In empty space, Khrunov and Yeliseyev, aside from the above-listed work operations, also set up and then took down the handrails for leaving the orbital compartment and transferring to the other ship, they set up and took down television lights, and simulated a number of assembly operations which might be needed in assembling large orbital stations for interplanetary ships and their repair.

During the flights of the American ships of the Gemini series, the work program in open space was fullest during the flight of the Gemini-12 spacecraft. The basic missions which were set for the spacewalk were the following. The pilot Aldrin, having opened the hatch, should conduct photographing, and set up a telescopic handhold. Then he was to go into empty space. Remaining in empty space for over 2 hours, he was to connect the rocket to a satellite (an Agena-12 rocket) with a 30-meter line, remove several adhesive tapes of varying length from the body of the ship and then reglue them to the side, slip a loop 5 cm in diameter on a hook with a spring-activated catch 5 cm in diameter, remove an electric plug from the socket and replace it in the socket, connect and disconnect the coupling of a pipeline used for connecting the spacesuit to the life support hose, using special shears to cut through, in turn, 6, 10 and 16-strand electric cable, using a special wrench to loosen and then fasten down two bolts 15.9 mm in diameter, as well as other operations.

The above-listed operations were to be carried out on two special work areas. One of them was set up in the forward portion of the Gemini-12 ship, at the point where it docked with the Agena-12 rocket, while the other lay in the auxiliary compartment. For holding the astronauts around the work areas, special grips were provided for the feet as well as loops through which the astronauts could hold on by hooks located on the ends of two nylon lines attached to the belt of the pressure suit. The length of the lines could be varied from 55 to 90 cm as the astronaut wished. In performing the operations, the astronaut was to use either the foot grips, or just the lines, or both simultaneously for holding his body in place. Moreover, the astronaut could move over the surface of the ship using the usual handgrips fastened to the ship, as well as with the aid of the extendable telescopic handgrip 2.4 meters long.

In addition to the special experiments to determine the work efficiency level of the pilot of Gemini-12 in empty space, Aldrin was also to perform a number of assignments related to space research.

The flight of Gemini-12 started on 12 November 1966. Due to the failure of the ship's locator, the rendez-vous and docking with the Agena-12 rocket were executed manually by the astronauts, pilot Lovell and copilot Aldrin. The docking operation was successfully carried out.

Some 19 hours and 29 minutes after the launch, Aldrin opened the hatch. Having stood up on the seat and put his shoulders out of the cabin, he set up the telescopic grip in working position and conducted a number of scientific experiments. After this he began to photograph the surface of the earth and the celestial bodies. Aldrin's work in the open hatch lasted 2 hours and 29 minutes, after which the hatch was closed.

Some 42 hours and 46 minutes after the start of the flight, Aldrin went out on the surface of the ship and moved to its forward portion where the docked rocket was. Here, using a 30-meter cable, he connected the rocket to the ship, and opened the shutters on the micrometeorite trap. After this, he removed the exposed and installed a new cassette in the movie camera. Then he moved to the "work area" in the auxiliary compartment, where he performed all the programed work operations. One of the bolts which had been loosened slipped from the astronaut's hand, but under the conditions of weightlessness it was easy to catch it. The astronaut performed all the operations without any particular effort.

The fastening of the astronaut's feet on the work area using special devices contributed greatly to the successful fulfillment of this program. The fastened feet made it possible for him to use his hands relatively freely.

Figure 6. The American Astronaut Edwin Aldrin on the Moon

This provided an opportunity to successfully perform even such a comparatively complex operation which at first was impossible as loosening and tightening bolts.

As a result of the flights of the Soviet and American spacecraft with the extravehicular activity, it was shown that on the surface of the ship it was possible to carry out a number of assembly and repair operations. This experience was needed in practice, when the astronauts had to intervene to eliminate accidental damage on the Skylab orbital station.

The Skylab orbital scientific station was launched into an orbit around the earth on 14 May 1973. A check of the station after entering orbit showed that the meteorite screen had pulled loose and jammed the basic panels of the solar batteries. All of this excluded the possibility of landing men on the station.

On the ground, several variations were worked out for repairing the loosened screen and solar batteries. On 25 May, the Apollo spacecraft was launched, with three astronauts on board: the commander Charles Conrad, the astronaut-physician Joseph Kerwin and the astronaut-pilot Paul Weitz. The astronauts approached the station to a distance of 1.5 meters. An inspection of the station showed that the protective screen and one of the solar battery panels had completely broken off, wehile a second panel had been wedged by a fragment of the screen. The first attempt to open up the remaining panel with solar cells was unsuccessful. However, the astronauts did everything within their power not to abort the work program for this station.

The astronauts, using the air lock, went into space and put the umbrella-type heat screen in the proper position. This made it possible to lower the temperature in the living compartments of the station to amounts acceptable for working. Then the astronauts, having made temporary handholds along the body of the station, completely deployed all three sections of the solar battery panel. Normal functioning of the station was restored.

A third spacewalk was made by the astronauts of the third crew of the Skylab orbital station, W. Pogue and E. Gibson. The astronauts repaired the drive of the radar antenna. The antenna had been jammed as a result of a short circuit in an electric circuit of the drive. The astronauts replaced five cassettes with film in the set of astronomical instruments, and also put up various devices for conducting scientific research on the exterior surface of the station.

During a flight, cosmonauts must live and work not only under the condition of weightlessness. In reaching the target planet and landing an expedition on its surface, the cosmonauts will encounter reduced gravity. For example, on the surface of Mars, the force of gravity is 2.5 fold less than on the earth. Cosmonauts encountered altered gravity at the first time in landing on the lunar surface. A person weighing 70 kg will weigh only 11.6 kg on the lunar surface. Since his muscular force remains the same, the pace and character of movements change significantly in comparison with what has been evolved on the earth. Long before the flights to the moon, K. E. Tsiolkovskiy wrote of those impressions which people should experience on our natural satellite: "Stones thrown upward ascend six fold higher than on the ground, and would come back very slowly so that it would be boring to wait.... I feel that I stand particularly easily, as if submerged up to my neck in water; me feet scarcely touch the floor.... I cannot resist the temptation of jumping.... It seems to me...that I went up rather slowly and came down just as slowly" [135, p 186].

Before preparing for the flight of the astronauts to the moon, the question came up of whether they in actuality from the very first step could coordinate their movements in altered gravity as well as Tsiolkovskiy imagined?

N. Armstrong was the first man to touch the lunar surface. After he opened the hatch of the lunar module, the astronaut crawled out to a nine-step ladder fastened to one of the four legs of the landing undercarriage, and began to descend. Along the way, having pulled a special rope ring, he deployed the television camera which transmitted to the earth a report on this historic event. Aldrin, in watching Armstrong descend, constantly corrected his movements: "Little to my side, move left, good, now everything is in order." At the same time Aldrin photographed Armstrong descending the ladder. Having descended the ladder, Armstrong took the first step on the lunar surface. "A small step by a man," he said, "and an enormous step for mankind." Then he took several more small steps in order to check

Figure 7. Astronaut H. Schmitt Sampling the Lunar Soil

the firmness of the lunar ground and the possibility of moving across the moon under the conditions of a six-fold reduction in gravity. His movements on the TV screens were like the movements of a diver on the sea bottom. He radioed: "I do not experience difficulty in movement. Here it is even easier than during training on the earth." He soon discovered that the lunar surface is covered by soft loose dust reminiscent of pulverized coal, under which solid ground can be felt, so that a foot sinks only several centimeters into the dust. On the TV screen you could see him leave the module. Turning slowly by 180 degrees, he raised his hand toward the TV camera. Then he began to take samples of lunar rocks with a special shovel and pack them in a cellophane bag which he then put in the pocket of his spacesuit. His movements became more and more confident and rapid. Then he moved even farther away from the lunar module and disappeared from the camera's view. Suddenly he appeared on the screen running across the moon. He was running, but not like a person running on the earth. His running was reminiscent of a person running as if filmed in slow motion. From the store hatch he took another bag for soil samples and again left the camera's range.

Then Aldrin appeared out of the module. He descended more confidently then his predecessor. Aldrin jumped down the last two steps. Armstrong photographed his descent. Aldrin stuck into the ground a stick on which an aluminized sheet was hung for collecting particles found in the solar wind.

At first the astronauts moved with great circumspection, but, having mastered it, they began to move with great fluid leaping steps with an average speed of 8-12 km per hour. "In my opinion," Armstrong radioed to the ground, "we have adapted to the 'one-sixth' without any difficulty."

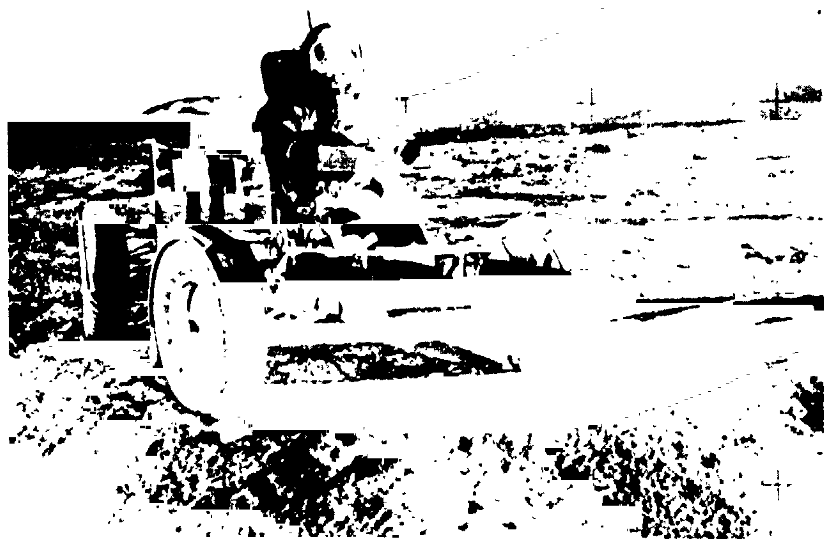

Figure 8. Astronaut E. Cernan Driving the Moon Rover

Upon returning to the earth, Edwin Aldrin thus described his impressions on moving over the lunar surface: "The moon is a quite convenient and very pleasant place to work. It possesses many advantages of weightlessness in the sense that any movement takes a minimum expenditure of strength. With its gravity of one-sixth of the earth's, you feel quite a definite sensation that you 'are somewhere,' and you possess a constant but at times erroneous sense of direction and strength. I would recommend that future astronauts devote the first 15-20 minutes of being outside the module solely to making certain that each man in his own way is able to work out a method for moving over the lunar surface.

"It turns out that under lunar conditions, it is not so easy to determine one's position in space. In other words, it is difficult to understand when you are leaning forward and when backward, as well as how strongly. This, as well as the field of vision which is rather limited by the helmet, lead to a situation where objects on the terrain have seemingly altered their curvature depending upon from where you are viewing them and how you are standing. The backpack on the moon weighs somewhat more than 20 pounds (1 pound = 453 grams, authors). On the earth, its weight is 124 pounds, but even this weight pulls you somewhat backward, and in order to balance it, you must lean slightly forward. It seems, someone described this position as the stance of a 'tired ape' standing almost straight, on semiflexed legs. At times it is difficult to determine whether or not you are standing straight. I determined this position, like my center of gravity, by swaying from side to side. The sensation is on the moon it is possible to lean much more on the earth to any side without losing one's balance. During the work we never fell. It seemed to us that it was very easy to kneel down and then get up.

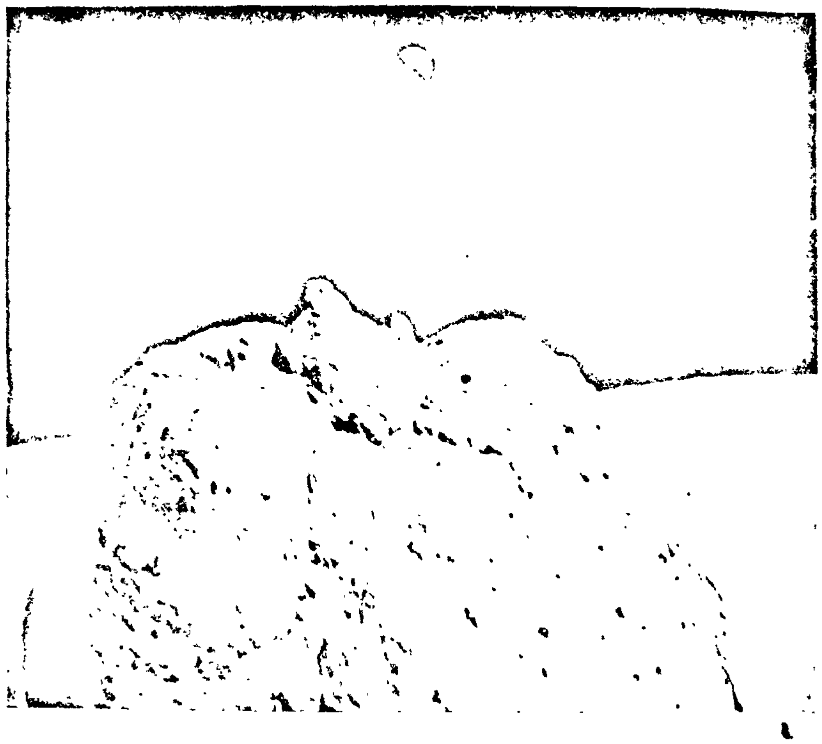

Figure 9. The Earth (Above) Photographed From the Moon

"The grip of the soles with the soil was less and the restoring of equilibrium was easier than during training in an aircraft with lunar gravity. The surface of the springy rubber mat in the aircraft was quite dependable, and the grip was good. But the situation was different on the moon. There was a significant change in the depth to which our feet sunk in this strange powdery ground. In many places we sank only a fraction of an inch (1 inch = 2.5 cm, authors), while the rim of certain small craters was covered by a deeper and looser soil layer. Our boots sank down 3-4 inches and slid a bit to the side until something solid was struck. Thus we tried to walk over level areas, avoiding depressions, and not to step on stones which were very easily moved. I stood up on one rather large stone, and it seemed to be slipping to me. This sensation was caused by the layer of fine dust covering it and by the particles of dirt which stuck to the soles of my boots.

"During the entire working time neither Neil nor I experienced fatigue, and there was no desire to stop and rest a bit. Certainly, we wanted to find out whether it would be hard to climb the ladder into the lunar module, and for this reason, before starting the work, I tried to jump onto the last step of the ladder. At first I did not know what strength would be needed, but after several attempts, I discovered that this could be done quite easily. Subsequently, I had enough strength to climb the ladder, skipping several rungs.

"Technically the most difficult for me was the taking of lunar soil samples, and for this it was essential to sink the sampler pipe into the ground. The soft, dust-like soil of the moon possesses amazing resistance even at a depth of several inches. This in no way means that it acquires the hardness of rock, however, at a depth of 5-6 inches, you begin to feel its gradual resistance. One other amazing thing was that with all its resistance, this soil was so loose that it would not hold the pipe upright. I had a hard time sinking the pipe into the soil, but it still continued to wobble from side to side" [56, pp 140-143].

In the future, when cosmonauts will fly to Mars and other planets, the amount of work will be increased in comparison with the lunar program. On Mars, they must conduct geological, chemical, biological, topographic, meteorological and other research. In carrying out this work, the changed gravity conditions will alter the biomechanics of movements, and consequently, in the future it will be essential to train the cosmonauts under simulated conditions of Martian gravity.

The Protracted Effect of Weightlessness on the Human Nervous System and Psychic State

> The human body consists of a mass of muscles which comprise our entire organism. Consequently, to abandon this portion of our body which is so historically trained at rest, and not to allow it to work--this is an enormous loss, and this must lead to a sharp unbalancing of our entire being.
>
> I. P. Pavlov

From a human anatomy course, it is known that muscles comprise around 40 percent of the human body's mass. They provide not only for the locomotion of man in the external environment, and one or another activity, but also the work of virtually all the inner organs. In the preceding section of the chapter, we have already written that in a state of weightlessness, there is no load on the muscles which work constantly under the conditions of gravity to maintain the vertical position (stance) of the human body. As was shown, this leads to a sharp reduction in the flow of nerve impulses from the muscles to the brain structures.

Blood pressure under the conditions of terrestrial gravity depends upon the strength of the heart contractions, the tension (tone) of the vessel walls and the weight of the circulating blood. Generally speaking, there is around 15 percent of the total amount of pressure for the weight of the blood which "disappears" in weightlessness. When a person is under the conditions of weightlessness, the hydrostatic pressure caused by the weight of the blood is absent. If it is considered that muscular activity related to keeping a person in a vertical stance also is eliminated, the strain on the cardiovascular system is significantly reduced. This leads to a reduction in the frequency of heartbeats and to a lowering of the blood arterial pressure. Thus, in carrying out the flights under the Vostok program, one could clearly see a tendency toward a slower rhythm of the work of the heart. In the flight of the ship Voskhod, it was possible for the first time to correctly measure blood arterial pressure. According to the data of the cosmonaut-physician B. B. Yegorov, during the flight the arterial pressure of V. M. Komarov dropped by 30 mm Hg, by 20 mm for K. P. Feoktistov, and by 15 mm for himself. Approximately the same picture was observed in the American astronauts. During the flights under the Mercury program, arterial pressure in the astronauts Cooper and Schirra was unstable. In the 14th day of the flight under the Gemini program, a reduction in arterial pressure and a slower pulse were noted in Borman and Lovell.

The reduction in blood pressure (arterial and venous) and the slower frequency of heartbeats, in turn, lead to a change in afferentation on the part of the cardiovascular system. Naturally, the question arises of how such changes in afferentation by the skeletal-muscular system and cardiovascular system are related to the psychic state of man?[1]

At the end of the last century, the pioneer of Russian psychiatry, S. S. Korsakov, was the first to focus attention on this problem. At that time, there was an interest in treating mentally ill persons by resorting to a strict bed regime (up to 8 and more months). In urging the physicians to have a strictly differentiated approach to prescribing a bed regime to the patients, and in also indicating the necessity of a scientific basis for the time of remaining in bed, Korsakov wrote: "It turns out that with extended lying in bed, a number of undesirable phenomena develop. For correct activity of the organism, there must be an alternation of quiet and movement, and abuse of either can be harmful both to a healthy person as well as, of course, a sick one. The harm from excessive quiet and from too extended remaining in bed may involve lymph and blood circulation since undoubtedly muscular movements are of significant importance for blood circulation, as well as a whole series of other important functions. Among other things, in theoretically arguing, it is impossible to deny the influence of confinement to bed on the mental sphere. Possibly, due to this in the hospitals where an extended bed regime is widely used in treating young patients there are so many cases of so-called juvenile feeblemindedness. In part is not this a form of the artificial aftereffect of too great mental laziness which develops in keeping with a strict bed confinement?" [92, pp 551-552].

Up to the present, in spaceflights there have been no special psychological studies aimed at disclosing the changes in all the basic psychic functions

1. Afferentation--the flow of nerve impulses reaching the central nervous system from the sensory organs and receptors innervating the muscles, vessel walls and inner organs.

as a result of altered afferentation by the skeletal-muscular and cardiovascular systems in a state of weightlessness. Nevertheless, we can judge these changes indirectly from the work efficiency and general feelings of the cosmonauts.

Analysis of work operations (radiotelegraphing, keeping of a log, and so forth), spectral analysis of speech, observation of external conduct during TV transmissions as well as analysis of the data from recording physiological functions made it possible for A. A. Yeremin and others [65, 66] to conclude that with a complicating of work activity for the cosmonauts and an increase in the length of the flight, fatigue is observed in a number of instances, and as a consequence, a reduction in work efficiency.

Regardless of the appearance of objective indications of developing fatigue, for the first 5 days the cosmonauts judged their state subjectively as good. This discrepancy between the objective data and the subjective sensations can be explained by the following mechanism. Physiologists and psychologists have long noted that an interest in work as well as great emotional stress do not provide an opportunity to "release" the protective mechanism manifested as fatigue. On the importance of involvement in work, V. M. Bekhterev has written: "Mental work to one degree or another excites and intoxicates, and this condition alone excludes a correct assessment of fatigue. A person during work itself may have no objective sensations of fatigue, but sometime later the indications of overfatigue appear in all clarity" [15, p 8].

As experience has shown, the cosmonauts begin to note the phenomena of fatigue on the 5th or 6th day of the flight. For example, this was evidenced by requests of the American astronauts during flights to the moon not to hold TV broadcasting sessions for the earth as previously planned by the flight program.

In an 18-day flight, according to the data of Ye. I. Vorob'yev and others [32], the cosmonauts A. G. Nikolayev and V. I. Sevast'yanov on the 10th-12th day of the flight, by the end of the working day, began to feel a certain fatigue which disappeared after sleeping. As N. S. Molchanov and others [154] have noted, the individual features of the cosmonauts during this time became somewhat aggravated. Nikolayev became more inhibited, and Sevast'yanov more talkative. Changes in the nervous system and psychic sphere occurred in the cosmonauts, regardless of the fact that during the entire flight, for 30 minutes twice a day, they performed a complex of physical exercises. The cosmonauts noted the effect of "muscular joy" from the physical exercises and a "charge of energy" for the entire working day.

It was discovered that the underloading of the cardiovascular system and particularly the skeletal-muscular system in a state of weightlessness leads to changes in the metabolic process, and in particular, for calcium. Thus, in the examination of American astronauts after the 4-day and 8-day flights under the Gemini program, it was possible to establish a reduction in the optic density of the bone proportional to the flight exposure. Research on the calcium balance during the 14-day flight of Gemini-7 disclosed an increase in the output of calcium and hydroxyproline in the urine, increasing toward the end of the flight. During an 18-day flight, the optic density of the heel bone of A. G. Nikolayev declined by 8.5 percent, and in V. I. Sevast'yanov by 9.6 percent.

The given data seemingly relate solely to physiology and not psychology, however, at present it has been established that an increased output of calcium is important not only for providing strength of the skeletal-muscular system and the normal functioning of a number of physiological systems, but also for the normal work of the central nervous system.

Figure 10. Cosmonaut A. G. Nikolayev After a Flight of Soyuz-9

The changes which occurred in a state of weightlessness were particulary apparent upon the return of the cosmonauts to the earth, that is, during the period of readaptation to the conditions of terrestrial gravity. Thus, upon returning to the earth after a 34-hour flight under the Mercury program, immediately after emerging from the ship, the American astronaut Cooper developed a prefainting state. He grew noticeably pale and things grew dark for him. During this time maximum blood arterial pressure dropped from 120 to 90 mm Hg.

Here is how A. G. Nikolayev described his sensations after an 18-day flight on the Soyuz-9 spacecraft: "I wanted to make my way more quickly to the persons greeting us, however, the consequences of the long flight immediately made themselves felt. It was difficult to get up out of the seat, as your body felt like it was full of lead and your legs were of cotton. Thus, you begin to perceive terrestrial gravity in an exacerbated way. It is difficult to get up, you feel your heart beating rapidly, your blood drains out of your head, and a gray veil appears in your eyes. You drop into the seat, as that is easier.... We passed our space 'baggage' through the hatch to the persons welcoming us. All the articles seemed very heavy. It was difficult to lift the ship log with one arm. The headset dropped out of Vitaliy's hands. Our comrades helped us out of the ship. It turns out that weightlessness is a rather serious joke. Medical examinations showed that during the flight I lost around 3 kg in weight, and Vitaliy lost almost four. This was not only a consequence of the dehydration of the organism, but also due to the breakdown of muscle and fat tissue. Moreover, a number of other changes were noted in the organism" [159, p 34].

From this description, it can be seen that the sensations of the cosmonauts after landing were not only unusual but burdensome. Upon emerging from the ship, they showed clear changes in the motor sphere. After landing it was difficult for them to maintain a vertical position. Nikolayev wrote: "Approximately 3 hours after landing, Vitaliy and I were allowed to walk by ourselves along the corridor to the mess for dinner. When we walked, we noticeably staggered. It was a good thing that the corridor was wide. Our movement along the corridor was filmed. Now, when we view these frames at Zvezdnyy Gorodok, our comrades make fun of us accusing us of having a glass of vodka after landing. But this was no joking matter for us. Any movement was accompanied by an increase in the heartbeat, by a reddening of the face, by neuroemotional stress, and by complete concentration of attention on controlling one's actions and efforts made. We walked with our legs apart in order to keep our balance. In moving one leg, the trunk shifted to the other support leg. The head was inclined somewhat forward and down in order to usually control the movements of the legs. Our arms were extended involuntarily to the side for maintaining equilibrium. Our steps were short and unstable in length. Our pace was of a 'stamping' sort and we could not walk a straight line" [160, pp 202-203].

The changes in movement coordination during the first 2 days of being on the earth were so significant that it was necessary for the staff to help the cosmonauts in moving about.

The dynamics of these disturbances were studied in greater detail by a group of scientists using the stabilography method. Stabilographic research disclosed a significant reduction in the vertical stability of the examined cosmonauts. Complete readaptation of the stance regulation mechanisms under gravity conditions occurred for the cosmonauts on the 10th day.

The transition from a horizontal body position to a vertical or sitting position during the first days after the flight entailed a worsening in overall feelings, an acceleration of the heartbeat and a drop in arterial pressure. It is interesting that even in a horizontal position, the cosmonauts felt a "pressing" into the bed. "After 18 days of weightlessness," related A. G. Nikolayev and V. I. Sevast'yanov, "the entire body (arms, legs and head) suddenly became heavy. The sensation was one as if you were sitting on a centrifuge under the effect of a slight acceleration. On the first day it seemed that this acceleration was approximately two units, or, possibly, slightly more. In subsequent days it gradually declined, and disappeared completely on the 5th or 6th day" [161, p 27].

In his book "Kosmos--Doroga bez Kontsa" (Space--an Infinite Road), Nikolayev, in returning to these experiences, writes: "With acceleration on the earth, I constantly had the notion that it would be a good thing if suddenly one could be returned to weightlessness and more humanely have a good sleep there and at least have a little rest from terrestrial gravity which was constantly pressing on us. Vitaliy suffered like I did. When I told him my idea of returning to weightlessness to sleep and rest, he immediately agreed. If this were possible, nothing better could be desired" [160, p 206].

The sensation of the constant effect of an overload after an extended spaceflight was new in comparison with the preceding flights. In the words of the cosmonauts, not only the extremities but even the inner organs felt very heavy. At this time, they noted pains in the muscles of the legs and back. Research conducted by M. A. Cherepakhin and V. I. Pervushin [219] showed that on the first day of the examination, the amplitude of the biopotentials of the muscles involved in realizing the knee reflex increased by two fold in Nikolayev, in comparison with the preflight data, and by three fold for Sevast'yanov. On the 3d day after the flight, the back strength of Nikolayev had been reduced by 40 kg, and by 65 kg for Sevast'yanov. The restoration of back strength occurred on the 11th day. In determining back strength, the cosmonauts complained of the appearance of pains in the leg and back muscles.

In measuring the perimeters of the extremities, a reduction in the circumference of the calves and thighs was discovered. The reduction in the perimeters of the lower extremities related to muscle atrophy was noted by the cosmonauts themselves during the flight. Nikolayev wrote: "During the second half of the flight, I noticed Vitaliy's legs, and said: 'Look, your legs are as thin as matchsticks, and before they were not.' And he, having looked at my legs, commented: 'But look at your own, they have also become thinner.' Muscle tone in the lower extremities in contrast to the arms was reduced. Hand strength was virtually unchanged, while back strength which depends upon the muscles of the back and the legs had noticeably declined" [160, p 124].

According to the data of roentgenological examination, the dimensions and volume of the heart in both cosmonauts had declined by 10-12 percent [154]. Blood research some 1.5-2 hours after landing also disclosed significant deviations from the normal.

As we have already stated, in a spaceflight the cosmonauts are exposed not only to weightlessness, but also to a number of other unfavorable factors. For this reason, for studying the effect of a reduction in afferentation from the cardiovascular and skeletal-muscular systems on psychic processes, the experiments in which the state of weightlessness is simulated are of great interest.

The extended effect of weightlessness on the human organism under ground conditions is simulated by two methods: by submerging the subjects in water and by observing a strict bed regime.

The idea of reproducing a state of weightlessness in a fluid medium belongs to K. E. Tsiolkovskiy who in his work "Grezy o Zemle i Nebe" (Visions of the Earth and Heavens) gave the following explanation of such simulation: "A person the average density of whom equals the density of water, being submerged in it, loses gravity, the effect of which is equalized by the reverse effect of the water." Incidentally, he here also pointed out that the illusion of weightlessness "will be far from complete" [40, p 171].

In one of the series of experiments, foreign researchers submerged the subjects completely in water. They were under water in a special device with an attachment for breathing and eating for up to 7 days. In these experiments, the task was posed not only of reducing afferentation from the skeletal-muscular system but also from the sense organs.

In this section of the chapter, we will describe the results of those experiments in which the sense organs of the subjects, upon being submerged in water, were completely loaded with information. An example of such a loading of the exteroreceptors can be the experiments of M. A. Gerd and N. Ye. Panferova [45]. Here the subjects were placed horizontally in a wide-mesh kapron netting in the upper water layer. The netting excluded the possibility of submerging, while the head was held in a special cushion in such a position that the face was always above the water. Feeding and servicing were also carried out in the water. Special assanation devices were used for handling physiological needs. The conditions for sleeping and wakefulness were the usual. The subjects were able to watch television, listen to the radio or tape recorder, and the reading of newspapers and books aloud was organized. The subjects could talk with the service personnel, and visits by friends were permitted. Such experiments in length did not exceed 15 days.

In simulating weightlessness by a strict bed regime, the subjects were prohibited from lifting their heads from the cushion or making sharp movements with their extremities. At the same time, they could watch television programs, listen to the radio, read books, and talk with one another (usually three-four persons participated at the same time in such experiments). In terms of duration, hypodynamia or hypokinesia (limited muscular activity) did not exceed 120 days.

Under the conditions of experimental hypodynamia, the same shifts in the various systems of the organism were noted as with the effect of weightlessness, however, they developed somewhat more slowly. In this research, it was also discovered that a stay in an immersion medium causes more profound disturbances than staying in bed.

The accumulated material on the problem of experimental hypodynamia made it possible for A. G. Panov and V. S. Lobzin [168] to establish the following three stages in changes in the central nervous system. The first stage (around 10 days) is characterized by the appearance of adaptive reactions in response to hypodynamia. On the 2d-3d day, all the subjects experienced dull pains in the lower back and the lower portion of the stomach and these lasted approximately 7 days. From the 4th day, a sensation of lability appeared, and this passed on the 8th-9th day. The pulse rate during this period declined by four-five beats in comparison with the initial data.

In the second, intermediate stage (also approximately 10 days), muscle pain completely disappeared. According to the data of Panov and Lobzin, the people feel well and are in a good mood, and sleep is normal. However, in this period, the electroexcitability of the muscles increases, the calcium content in the blood serum rises, and atrophy of the leg muscles starts. The pulse increases by an average of 10 beats in comparison with the initial. Arterial pressure is unstable and tends to drop. According to the data of Yu. N. Purakhin and B. N. Petukhov [178], in the middle or at the end of the second week, the subjects showed mild symptoms indicating the development of nervous system asthenization.

The third stage after 20 days of the experiment is characterized by a disruption of higher nervous activity and by an exacerbation of the disturbances of hemodynamics. The first signal of the incipient disturbances in higher nervous activity is the disturbance of sleep. Falling asleep becomes difficult (up to 3 hours), sleep is light, and dreaming assumes an unpleasant content. According to the data of T. N. Krupina and A. Ya. Tizul [96], after 20-25 days of the experiment, clear changes are detected in the neurological status (nystagmus, the pathologic Gordon and Oppenheim reflexes are caused, and a pathologic form of dermographism and other reactions develop). From the 30th day of the experiment, muscle tone begins to drop in all the subjects. Then the phenomena of muscle atrophy of the calves and thighs appear (lability, a reduction in circumference by 2-3 cm, a sharp drop in strength, and so forth).

By the end of the experiment which exceeded 60 days, the disturbances of nervous system functions and circulatory disturbances were maximal. Increased pulse and reduced arterial pressure occurred even with such an insignificant muscular effort as raising an arm. When the subject assumed a vertical position on the bed board, this was accompanied by a sharp increase in the pulse rate, by paleness of the skin, by cyanosis of the lips, by dizziness, nausea, darkening of vision and loss of consciousness. After the return of the subject to a horizontal position, an illusion of an inverted body position with feet upward occurred and lasted several minutes.

V. V. Parin, F. P. Kosmolinskiy and B. A. Dushkov have written that "a strict bed regime leads to immobilization, muscle atrophy and ultimately to the excessive secretion of calcium in the urine. This is related to the start of the demineralization of skeletal bones." They also note that "during the first minutes of completing a long experiment, a clear disintegration of motor structures is noted in walking, and expressed in the fact that the walking of the subjects is disrupted. Here an alternating of big and smaller steps is noted, and indications of discoordination arise. The synergy between the legs and arms customary for normal walking is disrupted. Arm movements become arrhythmic" [171, pp 188-189].

M. A. Gerd and N. Ye. Panferova [45] during their experiments observed a reduction in skin and proprioceptive sensitivity, a deterioration of movement coordination, an increase in the latent time of the motor reaction, and a deterioration of attention processes. The reproduction of time intervals also worsened. The data obtained in an associated experiment showed that during and after a stay under the conditions of hypokinesia, the latent period of speech reaction was increased. With good retention of thought in the subject, memory deteriorated. The execution of memory tests starting with the 5th-8th day was viewed as a process entailing a number of difficulties. The subjects sometimes doubted their ability for precise remembering, they referred to feebleness in seeking out images and concepts, and spoke of an unwillingness to make an effort.

Observations and questioning indicated that a negative attitude also arose to other forms of mental activity. A decline in the desire to watch television programs or listen to the radio was also noted. The subjects who had asked that books be read aloud refused to listen on the 2d-5th day; those who had started to study referred to the impossibility of surmounting the feeling of laziness, they pointed to the impossibility of concentrating effectively, and they complained of the lack of the ability to consistently reason out different simple and previously pleasant situations ("thoughts become short, they interrupt one another and often go off in different directions").

The impossibility of concentrating on something under the conditions of hypokinesia was noted by A. G. Panov et al. [169]. In their experiment, the subjects thus described this state: "Our thoughts began to be muddled...and thoughts were unrelated.... It was impossible to concentrate on anything." At the end of the second month of the experiment, the subjects began to note fatigue in reading and felt a heaviness in the head.

All of the researchers who have worked with subjects in hypodynamia experiments clearly recorded obviously expressed changes in the area of the emotional sphere. Expressed emotional responses appeared in virtually all the subjects in the earlier stages than did the changes in the other spheres of psychic activity. According to the data of M. A. Gerd and N. Ye. Panferova [45], many subjects who initially responded actively to various events in the experimental situation became apathetic: they lay silent, they sometimes intentionally turned away from people, and answered questions in a single word. Along with the development of apathy, pathologic forms of emotions were observed, for example, phenomena which previously had constantly been perceived as positive began to be perceived as negative (colors and music were irritating, and the subjects refused to meet with friends).

Male subject A. in the experiments of P. A. Sorokhin et al. [192] in his diary during the 7th week wrote: "My mood changes like the Leningrad weather. I am as fed up with this diary as with hypodynamia. Generally I feel better when no one is around and no one laughs." This subject, as the authors pointed out, excelled in particular eventemperedness and balance.

In the experiments of V. P. Bogachenko [17], upon questioning all the subjects stated that they "were fed up with everything," "were fed up with being examined," "there were days when everything was spinning inside," "even film comedies did not improve the mood," and "the presence of physicians is irritating."

In certain subjects, a phenomenon was noted which was termed by M. A. Gerd and N. Ye. Panferova as "emotional simulation" expressed in the attempts to artificially maintain a good mood (the subjects laughed forcibly, they conversed loudly and sang). However, in the course of the experiment such concealment of feelings gradually disappeared, and more and more often was replaced by an unconcealed bad mood. After 7-9 days, virtually all the participants were unable to conceal their mood. After 7-11 days, an inadequate response to unimportant factors was noted. An anxious state and fear appeared, and here such responses as the shaking of the arms, the quivering of lips and chin and the reddening of the face were noted.

The authors particularly brought out the fact that in response to insignificant unpleasant situations, tears appeared in the eyes of four men 23 years of age. This shows the extreme degrees of emotional and volitional exhaustion. During the experiment, a majority of the subjects complained of a lack of sleep, regardless of a clearly expressed desire to sleep. In order to fall asleep at night, the subjects endeavored to remain awake during the day, and, nevertheless, were unable to fall asleep.

Before the end of the experiment (some 5-10 hours), a state of euphoria was observed in a majority of the subjects. Its appearance was related to the development of a joyful mood over the ending of the experiment. The subjects gradually lost control over speech activity. They became unrestrained and talkative. In a number of instances, the tasks of the experiment were carried out more rapidly but with a large number of mistakes. In some subjects, this state lasted for several hours after the end of the experiment.

Yu. N. Purakhin and B. N. Petukhov [178] also observed the appearance of symptoms indicating disturbances in the emotional sphere of the subjects. A. G. Panov et al. [169] noted that sleep and the emotional sphere were the most susceptible with asthenization of the nervous system during hypodynamia. In certain instances, the disturbances of the emotional sphere grew into a sharply expressed neurotic state.

Thus, in one of the four subjects in the 62-day experiment for hypokinesia, from the second half of the 20th day, the condition sharply deteriorated. He "began to confuse thoughts," and "was unable to concentrate on anything." An acute sleep problem developed, and "unmotivated" crying and a compulsive insurmountable desire to move appeared. On the following days, he endeavored to make all sorts of movements and get up from the bed. To questions he replied quietly, in a single word and with a dry voice. Due to the acute neurotic state, the testing was halted. In another experiment, according to the data of A. G. Panov et al. [169], the male subject C., on the 69th day of hypodynamia, showed an increased depressive mood, sleep was disturbed and a feeling of fear appeared.

V. P. Bogachenko [17] has also given an example of a disturbance of neuropsychic activity under the conditions of hypodynamia. The mood of male subject K. deteriorated sharply. The two previous nights before this he had slept little and his sleep was interrupted. He answered questions unwillingly, his voice was dull and monotonous, and his responses terse. He began to cry. He complained of dull headaches, a heaviness and feeling of warmth in the head. A shaking of the fingers was noted and his arms were extended. The neurotic reaction of K. was so expressed that the experiment had to be stopped.

I. A. Maslov [150] in hypodynamia experiments lasting from 15 to 120 days also noted a number of psychic disturbances such as hypochondria, insurmountable fear, rather expressed depression, and so forth. For example, one of the subjects during the experiment began to act with caution, with a certain anxiety he began to analyze his state and listened to the conversations of the experimenter physicians; he endeavored to catch from the conversations facts which could threaten his health. He refused to eat certain foods, without giving any valid reason for this and endeavoring to escape by general arguments that these products had "little salt," they did not give him an appetite, and so forth, although outside the experiment he often ate these foods.

A second subject in the process of the experiment began to behave in a distant and shut-off manner. Upon being questioned about his condition, he replied briefly and formally. During the experiment he began to experience an uncertain fear, he hid his feet under the blanket, and it seemed to him that someone intended to stick him with a needle. He did not show sufficiently reasonable criticism of his state. But after the experiment, he himself laughed at his fears.

A third subject began to complain of a general malaise, but was unable to say precisely what it consisted of. He was experiencing strange sensations in his head ("something is twitching"), and said that at times upon falling asleep, with his eyes closed, it seemed that his head "was falling to the side." And one other subject during tense moments of the experiment showed a severe response of excitation with expressed depression, insomnia and severe headaches. At one such moment he complained that he "feared for his reason."

In completing the examination of the effect of hypokinesia on the psychic state of the subjects, it is essential to point to the modifications of experiments in which in one instant the subjects, being in a horizontal position in bed, intensely partook in various physical exercises under special programs. In another, the subjects were given various medicines which affect muscle tone, the cardiovascular system, the nervous processes and other functions of the organism. Regardless of the use of the designated measures, the subjects (although more slowly in comparison with "pure" hypodynamia) still developed the above-described changes in the cardiovascular and skeletal-muscular systems, in higher nervous activity as well as in the psychic sphere. For this reason the combating of the deleterious effect of weightlessness under the conditions of a long flight assumes so great urgency.

Certainly a cosmonaut is a person from our planet for whom not only favorable conditions for work and life during the flight must be created, but also everything possible must be done so that upon returning to the earth he has remained healthy and also could work successfully in that environment to which he has grown unaccustomed during the flight.

Measures for Protecting Cosmonauts Against the Deleterious Effect of Weightlessness

> Movement as such can in terms of its effect replace any medicine, but all the medicines of the world are unable to replace the effect of movement.
>
> A. Mosso

From the very start of spaceflights, time was scheduled for conducting physical exercises using rubber exercisers for preventing the development of the undesirable consequences of the effect of weightlessness in the life of the cosmonauts. Up to the 18-day flight on the Soyuz-9 spacecraft, sports training provided rapid readaptation of the cosmonauts upon returning to the earth. But this flight also showed that in increasing the length of exposure to weightlessness, one must not be limited to just physical exercises using the rubber exercisers. For this reason, on board the Salyut orbital station, great attention was paid to maintaining the tone of antigravity musculature, the cardiovascular system and other functions of the organism.

Aside from different physical culture devices made from rubber and springs, the Salyut also carried a so-called treadmill which was a circular belt on rollers. By fastening themselves to the floor of the cabin with rubber straps, the cosmonauts could run and walk on it. The taut rubber straps simulated terrestrial gravity. In holding on to two rubber straps simultaneously, it was also possible to put a load on the arm muscles as in running. Two hours a day were given by the cosmonauts to physical exercises.

Although the sports exercises had a planned character, still they were an episode in the life of the men in orbit, while the force of gravity operates constantly under the conditions of the earth, causing the constant work of the antigravity muscles of man. A special suit was used on the Salyut orbital station for a constant load on the human skeletal-muscular system. This suit, with the aid of a complicated system of straps, created a load on the skeletal-muscular system of the trunk, on the calf, thigh and arms, on virtually all groups of muscles, and respectively, on the joints and bones. It was planned that the cosmonaut would do his physical exercises in it, but the basic thing was that he should wear it constantly. To the question asked the crew members of the Salyut orbital station from the ground: "Are you constantly using the tightening system on the load suits?" G. T. Dobrovol'skiy replied: "Yes, we are using the load suits constantly, and are even trying to sleep in them if possible" [183, p 125].

With the absence of the forces of gravity, as was shown by us in the preceding sections of this chapter, a rather rapid readjustment of blood circulation

Figure 11. Cosmonaut V. I. Sevast'yanov Performing a Gymnastic Exercise With an Exerciser During the Flight of the Soyuz-9 Spaceship

is observed and manifested, on the one hand, in the redistribution of the blood (an increased influx into the area of the upper half of the body), and on the other, in a deterioration of the tolerance for the forces of gravity upon returning to the earth. For a majority of people leading an ordinary way of life, the physiological mechanisms for regulating blood circulation are rather effective. At the same time, for maintaining the proper mobility of these mechanisms, their constant training is required. If these mechanisms are not activated over a certain period of time, for example, with extended hypodynamia, they become "out of shape." And if a person is moved sharply from a horizontal to a vertical position, usually the phenomena of a faint are observed caused by the fact that the blood circulation apparatus is unable with the necessary speed and to a sufficient degree to provide the efflux of blood from the lower part of the body and its redistribution in the direction of its upper part, and in particular, to the brain.

For training the cardiovascular system for the redistribution of blood, the orbital station carried a special unit, a vacuum container. In appearance it is reminiscent of a "barrel," within which a negative pressure can be created. The cosmonauts lowered themselves up to their waist in this device and created in it an adjustable negative pressure using a micro-compressor. The amount of pressure was controlled by a barometer.

With a drop in pressure, the blood flowed into the vascular channel of the legs and pelvis. and in terms of its character this was very reminiscent of the efflux arising under the conditions of the force of gravity with a vertical position of man. The cosmonauts praised this device. The data obtained in the process of an extensive complex of medical research indicate that the cosmonauts maintained a good "terrestrial" shape during the entire flight.

The complex of physical exercises on the Salyut-3 orbital station was significantly improved in comparison with the complex of the first Salyut. Upon returning to the earth, Yu. A. Artyukhin thus described the training on the comprehensive trainer for physical exercises: "The first impression from the physical charge on the trainer was a very great lightening. During the first days in space, as you know, there is a period of adaptation, the blood flows into the head, it [the head?] grows heavier, and the state is not one of the best. But then, on the 2d day on board the station, I worked on the trainer, and a feeling appeared that these unpleasant sensations had been reduced by at least half. And 5-6 days later, in exercising on the trainer, you totally forgot where you were, and you felt like you were under ordinary ground conditions. Weightlessness is not felt at all, only when you get out of the trainer, you involuntarily fly up to the ceiling, because out of inertia you have pushed off strongly. The results of the exercises on the trainer can be seen from the fact that hand strength which we regularly checked using a dynamometer, by the end of the flight had increased. This was totally unexpected for the medics."

During the first minutes after landing, for cosmonauts P. R. Popovich and Yu. A. Artyukhin, because they were no longer accustomed, all articles seemed heavy. Significantly less time was needed than for the crew of Soyuz-9 for the cosmonauts to readapt to terrestrial gravity. Rapid re-adaptation to ground conditions was explained by the fact that the cosmonauts during the flight had performed a complex of physical exercises that was longer than during the flight on the Soyuz-9 spacecraft, as well as by the fact that there were special trainers on board the Salyut orbital station.

On the Salyut-4 orbital station, in addition to the treadmill and the vacuum container, there was also a veloergometer. After the month-long stay under the conditions of weightlessness, the cosmonauts A. A. Gubarev and G. M. Grechko readapted rather quickly to ground conditions. On the day of landing or "zero day" the research indicated that the cosmonauts were lively, active, and well-oriented, although the sense of equilibrium was somewhat disturbed. A certain fatigue was noted, and this disappeared after intense work. During the flight, the commander lost around 2.5 kg in weight, and the flight engineer 4.5 kg. But during the first days of rest, they rapidly began to put on weight.

A broad range of sports training was also carried out on the Skylab orbital station. Upon returning to the earth, the American astronauts also showed a rather rapid readaptation to the effect of gravitational forces.

The remaining of man in a state of weightlessness in and of itself causes many inconveniences, and creates a constant psychic stress.

"We decided to sleep in the orbital compartment," wrote V. N. Volkov. "I occupied the 'sofa.' Having slipped my sleeping bag under the straps of the 'sofa,' I crawled into it and tried to make myself more comfortable. While the midsection of my body was somehow pressed to the 'sofa,' the situation was worse with my head and legs, as they floated about. I began to search for a somewhat more or less acceptable position. No, nothing could be found. Certainly there was no cushion to which we are accustomed on the earth, and most importantly, there is nothing to press against. But still a solution was found. I rested my feet on the wall of the compartment and my head against the housing of the sextant which stood there in a bracket. Anatoliy made himself comfortable on the sidewall of the 'sideboard,' while Viktor crawled into his sleeping bag having attached the ends of it with a line to the handholds. He was suspended between the 'ceiling' and 'floor.' A real hammock was produced. I did not envy him. Tomorrow, according to the established rotation, it was my turn to sleep in this position" [30, pp 129-130].

In the opinion of many researchers in the area of space physiology and psychology, the basic means for protecting the cosmonauts against the deleterious effect of weightlessness in a long spaceflight will be an artificial force of gravity (AFG) created by rotating the ship around the center of mass. The idea of creating an artificial force of gravity during a spaceflight belongs to K. E. Tsiolkovskiy. In his work "Issledovaniye Mirovykh Prostranstv" (Research on the World's Expanses) in 1911 he wrote: "Even if it has turned out that people cannot live without gravity, it would be easy to create it artificially in a medium where it does not exist. For this it is merely a matter of spinning the man's dwelling or rocket, and then, as a consequence of centrifugal force, a seeming gravity of the desired amount would be formed, depending upon the size of the dwelling and the speed of its rotation. This gravity is convenient in that it can be as small or great as one wishes, and it can always be eliminated and then restored."

We can judge the beneficial influence of even an insignificant artificial gravity measured in several hundredths of a percent from the statements by cosmonauts. As we have already written, after the ship entered orbit, the cosmonauts in a state of weightlessness experienced a sensation of the flowing of blood into the head. The sensation of the flow of blood to the head and the intumescence of the skin and mucous membranes of the face declined noticeably, when, with a so-called twist of the ship, the cosmonauts assumed a longitudinal position with their head toward the center of rotation along the vector of the centripedal force. "Adaptation (becoming accustomed) to the conditions of weightlessness occurred rather easily for us," writes A. G. Nikolayev. "In truth, at the start of the flight, we, like other cosmonauts, sensed a flow of blood into the head, and this caused a certain puffiness of the face. But this sensation was familiar to us, and we had experienced it on the ground, when we slept at the space center with a negative incline angle of the beds. We were so accustomed to it that it did not prevent us from working normally. Moreover, in space, if you stood 'upside down,' that is, put your feet not on the floor, but on the ceiling of the orbital compartment, this sensation almost completely disappeared. Why? Because the body was lying along the centrifugal forces which arose with the spinning of the ship in the sun. Although the spinning was scarcely noticeable, the blood flowed from the head to the feet" [160, p 81].

With the creation of AFG, even the slightest, the human body and the objects around acquire a weightness, and "up" and "down" appear. Artificial gravity will stimulate the work of the cardiovascular and skeletal-vascular systems as well as other functions of the organism. Of course, AFG does not exclude but, on the contrary, presupposes a broad range of sports measures on board the ship using various devices. In particular, opinions have been voiced on creating a special area in the interplanetary ship where a centrifuge will operate. On this centrifuge, the cosmonauts will receive "doses" of terrestrial gravity, as well as acceleration which they will encounter in landing the landing module on the planet to be examined and upon returning to the earth. This entire complex will make it possible to protect the organism of the cosmonauts against the harmful effect of weightlessness, and maintain mental work efficiency.

From physics, it is known that the weight of the body upon rotating depends upon the angular velocity and the radius of the circumference around which the movement occurs. A calculation has shown that for creating artificial gravity equal to the earth's, a rotating ship must have a radius of several hundred meters. If the radius is less, it will be necessary to increase the rate of spin, and this can create a deleterious effect on the mental state of man, as a consequence of irritation to the vestibular apparatus.

The first work on experimental physiological setting of the minimally effective AFG necessary for maintaining a normal stance and movement coordination was carried out immediately after the flight of Yu. A. Gagarin. The research was done on animals.

As the amount of centripedal acceleration necessary for creating the minimally effective AFG, one was used whereby the position and character of the animal's movements were analogous to their ordinary conduct under laboratory conditions. Analysis showed that under the conditions of weightlessness, the animals spun chaotically in various planes, and sometimes two or three simultaneously.

In creating AFG with an acceleration from 0.05 to 1 g, the character of the motor activity of the animals changed substantially. According to the increase in the amounts of reproduced acceleration, movement more and more approximated the characteristic sort for terrestrial conditions. With low accelerations, the animals were carried to the wall of the device, however, up to accelerations of 0.08 g for mice and up to 0.18 g for rats, semiturns around the longitudinal axis of the body were at times observed.

With higher acceleration values (up to 0.28 g), the animals already rested their extremities on the surface of the device and attempted to move along the walls, however, their paws slid, the movements were very frequent, and the direction of movement constantly changed.

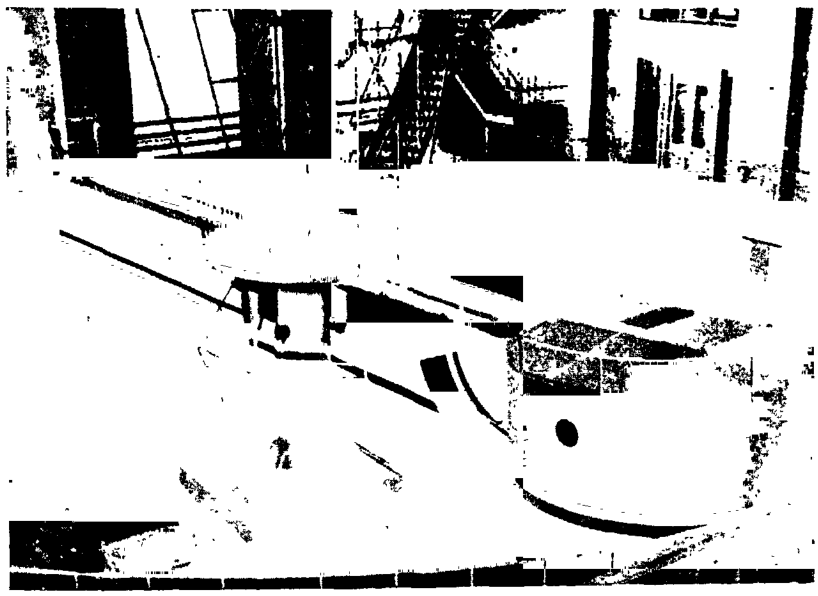

Figure 12. The "Orbit" Stand for Studying Extended Rotation on the Human Organism

In creating accelerations of 0.28-0.3 g, the behavior of the animals during the flight was the same as under laboratory conditions. The animals assumed either the characteristic "sitting" position for them, or moved slowly and calmly. Beyond the designated boundary, their movements in all instances became smooth and sufficiently coordinated.

Although the motor activity of the mice and rats in a state of weightlessness varied, the amount of acceleration necessary for the complete restoration of the coordination of their movements and stance in both instances was the same. On this basis, an acceleration of 0.3 g was accepted as that minimally effective amount which is essential for creating artificial weightness.

This tentative calculation was clarified in subsequent experiments on other animals. Here, the criterion for the amount of acceleration necessary for creating AFG was not only the motor acts, but also other indicators characterizing the state of the organism's motor system. In particular, in experiments with the recording of bioelectrical activity from the muscles, it was discovered that the first indications of an increase in it, in comparison with the activity of muscles under weightlessness, arose with AFG = 0.15 g. Within the limits of from 0.15 to 0.28 g, the value of the biopotentials rose in parallel to the increase in the transversely acting g-load. The amplitude characteristics of bioelectrical activity with artificial weightness equal to 0.28-0.31 g equaled the amount of customary terrestrial conditions.

Subsequently, regardless of the increase in the amount of the effective load up to 0.6-0.7 g, no marked increase in the amplitude of the biopotentials was observed, and their value equaled in fact the amplitude at

0.28-0.31 g. In line with this, as well as on the basis of data concerning the "normalization of electroactive skeletal muscles of animals," the conclusion was also drawn that an acceleration of 0.28-0.31 g can be recognized as the minimally effective amount of artificial weightness.

American researchers obtained approximately the same results in their research on the given problem. According to their assertions, an acceleration of 0.27 g can be considered sufficient not only for preventing motor disturbances in animals, but also for normalizing human motor reactions.

In examining the physiological and psychological problems of AFG it is essential to consider that its value will depend also upon the state of the vestibular analyzer. Research on the viability and adaptive processes in man to extended rotation was started by A. V. Lebedinskiy with a group of scientists [128]. During the first stages, a larger share of the research was conducted with rotation not exceeding 1 or 2 days in duration. In 1964, the American researcher /A. Graybill/ conducted a 2-week experiment with continuous rotation at a speed of 18 degrees per second. In 1965, the same researcher with associates published the results of experiments of spinning at a speed of 60 degrees per second and a duration of 12 days. R. R. Galle and M. D. Yemel'yanov [43], in the course of experiments on spinning subjects for 7 days, established the onset of stable adaptation to spinning at a speed of 10 degrees per second and partial adaptation at a speed of 40 degrees per second.

Figure 13. Subjects in the Living Module of the "Orbit" Stand During a Month-Long Spin

Not so many works are devoted to researching the vital activity and adaptive processes in man under the conditions of protracted spinning. All these data have been generalized by Ye. M. Yuganov and M. D.Yemel'yanov [229], and in terms of the tolerance of extended rotation by a healthy man with high stability of vestibular functions (with a rotation radius from 1.5 to 7 meters and centripedal acceleration up to 0.3 g) they have reached the following conclusions. In spinning at a speed of 60 degrees per second, the tolerance time reached 4 hours, at 40 degrees per second it was 7 days, and at 36 degrees per second some 14 days (permanent adaptation).

For further studying the effect of extended rotation on the human organism, in the USSR a special "Orbit" stand was developed with a living module, the volume of which was 14 cubic meters. The module contained comfortable sofas, a table, TV, radio, toilet, shower, and so forth. The living module was attached to the arm of a centrifuge (a radius of 10 meters) which at the same time served as a corridor by which the living module could be reached during rotation. During the rotation, the cabin was tipped, but regardless of this, the subjects were always perpendicular tc the floor. All of this made it possible to conduct experiments lasting up to 40 days and more (see Figures 12-13 kindly provided to us for publication by L. A. Kitayev-Smyk).

On this stand, Soviet physiologists L. A. Kitayev-Smyk and R. R. Galle conducted several series of experiments with a rotation speed of 24 and 36 degrees per second. This showed that a person can adapt to rotation at a speed of 24 degrees per second and maintain the ability to work for a month. However, this does not mean that the phenomena of discomfort completely disappear.

A disruption of the ability to work and the development of the motion sickness syndrome, in the opinion of these researchers, are related predominantly to the effect of Coriolis acceleration. With reduced assistance of the vestibular analyzer, the tolerable rotation values, naturally, decline. "Considering the numerous both labyrinthine and extralabyrinthine factors," write Ye. M. Yuganov and M. D. Yemel'yanov, " which determine the development of adaptation to rotation, as well as the results of the experiments of the mentioned researchers, a speed of 10 degrees per second can be proposed as an initial optimum value for extended rotation. It is not to be excluded that subsequently, with the broadening of our knowledge on the function of the analyzers in a state of weightlessness, this value can be made substantially more accurate" [229, pp 48-49].

Calculations indicate that in order to achieve an artificial gravity equal to 0.3 g with a rotation speed of 10 degrees per second, the radius of the spacecraft should be 90 meters.

In the opinion of some designers, in order to embody these calculations in reality, the spacecraft possibly should be built in the shape of a large ring ("doughnut") or as a "dumbbell." These structures during the flight would rotate constantly around the center of mass. Of course, the realization of these ideas entails significant technical difficulties, but there is no doubt that they will all be surmounted, and AFG will be created on an interplanetary ship.

CHAPTER V: THE EFFECT OF ISOLATION ON THE PSYCHIC STATE OF MAN

Under the ordinary conditions of life on earth, hundreds and thousands of different pictures of nature and the creations of his own hands flash before the eyes of man. The hearing organs are constantly exposed to all sorts of sounds, in creating a different voiced acoustical background. The skin receptors perceive temperature changes.

In an interplanetary flight, for months the cosmonauts will see through the windows only the bright unblinking stars against the black abyss of the skies and the blinding disc of the unsetting sun. There will be neither day, night, nor winter or summer to which the people on our planet are so accustomed. Beginning even with the first flights to the moon, the crew members of the Apollo spaceships complained of the monotony of impressions on the "leg" between the earth and the moon. When the ship's cruise engines had ceased firing, the cosmonauts enter the realm of silence. The silence of the spaceship quarters will be disrupted only by the slight and monotonous noise of operating air conditioners and the electrical and other equipment.

Here is how A. G. Nikolayev describes space quiet during orbital flights: "During the flight we rapidly grew accustomed to the quiet, monotonous noise of the work of the instruments, electric motors, ventilators, recovery unit, the air conditioner and the ship's clocks. From the characteristic noises we could follow the passage of commands from the program timer. We could clearly hear the tripping on of the selected program, the firing and shutting off of the basic engine and the thrusters and the working of individual valves. Soon from these characteristic sounds, we could clearly analyze the work of the ship's various systems. We became so accustomed to these characteristic sounds that they did not bother us at work or during sleep" [160, p 109].

As observations show, a lack of an influx of stimuli leads to a unique experience which has been termed "sensory starvation." While "information starvation," as we have already said in the third chapter, is caused by a "lack of food" for the second (verbal) signal system, the "sensory starvation" is caused by a lack of impressions from reality for the first signal system.

"Sensory Starvation"

> Desire, both from the psychological and the physiological standpoint, can generally be placed next to the sensation of hunger. A visual desire differs from hunger, thirst or voluptiousness only in the fact that an image concept is related to the trying sensation common to all desires; in auditory desire, the notion of sound is found along with languor, and so forth.
>
> I. M. Sechenov

"In a spaceflight," writes A. G. Nikolayev, "we lack the terrestrial sounds and phenomena which are customary for man. There we could not hear the noises characteristic for the city or countryside, the noises of the forest and the wind, or the singing of songbirds; there was no aroma of beautiful flowers or the earth, water and forest. It was neither hot nor cold for us. We did not feel the wind, the rain, there were neither snow nor blizzards. We truly longed greatly for the customary terrestrial sounds, phenomena and smells. Sometimes, we felt, heard or saw all these terrestrial things in our sleep" [160, p 109].

Life in Antarctica, in the opinion of R. Byrd, in many regards is reminiscent of life "on a dark, dead and frozen planet" [27, p 129), since during the long months, the station based in the frozen immobility of an icy world becomes as unreachable as a distant planet. The unsetting sun in the summer and the constant light of the moon and the blinking of the stars of the polar night in their constancy bring life close to conditions of a long spaceflight. The necessity of the winterers to spend a larger portion inside has much in common with the life of a crew on an interplanetary ship.

"The arctic night holds something supernatural," wrote C. Borchgrevink in his book "Y Yuzhnogo Polyusa" (At the South Pole). "Possibly, the spell of unbroken solitude intensifies an awareness that we are cut off from all mankind. It was interesting to see how the unsetting moon described a complete circle in the heavens. For many days it did not set, but only touched the mountain peaks, causing there a fantastic play of light and shadow" [23, p 96]. And in another place: "In such weather (meaning the extremely low outside air temperature, authors), life in our small quarters seemed sometimes unbearable. We did not have enough light, movement or air. We literally aged before our very eyes.... At times silence rang in our ears, and any disruption of the terrible emptiness and isolation was a pleasure.... Thus passed the long and dark days of winter without change. Time passed slowly and boringly, and only the obligatory reporting of instrument readings introduced a certain diversity" [23, pp 94, 108].

The depression of the polar night was felt particularly strongly in the past, when the research parties were small and the winterers had neither electricity, radio nor movies. With the development of civilization, the problem of monotony under arctic and antarctic conditions has not been completely eliminated. "Regardless of all these improvements," wrote R. Byrd, "life continued to remain difficult and miserable. Movies and electric light helped for several hours to dispel the gloom and emptiness of the polar night, but we were never able to lift the depressing burden of darkness which hung over us. Nothing could replace sunlight, and the absence of it was reflected painfully in the psyche of the men.... The total darkness which accompanied snowstorms had a depressing effect on the human psyche and caused a feeling of unreasoned panic" [27, pp 150, 162]. Something similar has been pointed out by V. V. Boriskin and S. B. Slevich: "The meteorological factors merely contribute to the monotony and the uniformity of the way of life, since they limit the opportunity to remain out of quarters. This monotony is expressed particularly sharply during the winter months, and for this reason, precisely during this season instances of a general deterioration of health, inhibition, withdrawal, short temper, and increased irritability are recorded, in a word, psychic incompatibility is manifested in its most acute form. Changes in the health state of polar workers caused by extended sensory insufficiency and viewed as uncompensated reactions from the central nervous system can have a varying character. This may be the inadequate reaction to certain comments, sometimes assuming a hint of pathology. Such a state of a polar worker has been defined as neurotic. In extreme instances, the disturbance in the activity of the nervous system leads to psychoses and to the appearance of the symptoms of phobias, that is, an obsessive state of fear which develops during certain mental illnesses" [21, p 33].

Mario Mare has written about sensory starvation under antarctic conditions: "I would willingly have given up my salary for a month or even two for the sake of seeing green grass, a flower-carpeted meadow with grazing cows, or a birch or beech grove with turning leaves with autumn rains running off them" [148, p 86].

The feeling of "sensory starvation" has also been clearly manifested under the conditions of experimental individual and group isolation. Male subject C., in the experiments of Ye. M. Krutova, in being in an isolation chamber, described his state on the 5th day as follows: "I had a strange feeling, exactly as if I was being deprived of air, as if I lacked something but could not understand what. I carry out the assignments without any initiative and unwillingly. My brain works somehow reluctantly, and I constantly catch myself in the thought that it is not I but someone else who is doing all this. I do not even feel like answering questions" [97, p 75].

The journalist Ye. Tereshchenko who participated in an experiment under the conditions of group isolation wrote these lines in his diary: "Watch, dinner, examination and sleep, our entire life is governed by a feverish but monotonous rhythm. Gradually nervous fatigue began to make itself felt. We became more irritable. It became harder to make oneself work. More and more often you wanted to open a door to somewhere and see something else. It made no difference what, as long as it was new. At times you had a terrible wish even to the point of crying, to see a bright, definite and simple color of the spectrum or a red calico poster or the blue sky. Tedium" [198, p 38]. And the physician Ye. I. Gavrikov has written: "Today I suddenly felt like walking over asphalt, looking at trees, as it was midsummer....

Today I thought how very pleasant it would be to put even a small bunch of flowers on our table...."

Four months after the start of a year-long experiment in a ground complex through the air lock the subjects in honor of Cosmonautics Day were given congratulations from friends and a toy, a yellow chick. On the occasion of this event, A. N. Bozhko wrote in his diary: "It is strange that we are pleased by each vivid trinket. Possibly because we are surrounded by gray tones?" [18a, p 98].

Over 100 years ago, in his classic work "Refleksy Golovnogo Mozga" (Reflexes of the Brain), I. M. Sechenov wrote that one of the necessary conditions for normal human psychic activity is a certain minimum of stimuli reaching the brain from the sense organs. "This proposition from I. M. Sechenov," wrote I. P. Pavlov, "was subsequently brilliantly substantiated in a clinical case. Accidentally, Prof Strumpell happened to have a patient in the hospital whose nervous system had been so impaired that only two eyes and an ear remained of all the perceiving surfaces. And as soon as these last surviving windows from the outside world were closed, the patient immediately fell asleep. Thus, it was fully substantiated that for a wakeful, active state of the large hemispheres there must be a certain minimal influx of stimulation. Quite recently...I happened to see a similar case.... When his (the patient's, authors) healthy ear and healthy eye were open, he understood us completely and could read and write. As soon as either his ear or eye was closed..., he immediately fell into forgetfulness, and could not remember anything which occurred to him during this interval" [166, pp 186-187].

Aviation physicians during the period of World War II also encountered the effect of altered afferentation on the mental state of persons on a mass scale. During flights the pilots developed a sleepy state and a feeling of apathy. In the 1950's, with the changeover of aviation to jet equipment making it possible to increase the speed and altitude of the flights, along with the above-indicated state, with high-altitude flights the pilots began to complain of a feeling of physical separation from the earth to such a degree that they began to feel that they were completely losing contact with the earth. In aviation this phenomenon was termed "break-off." Here is how its manifestation has been described by the American physician D. Simons who for experimental purposes in 1957 ascended to an altitude of 30 km in an air balloon: "On the 2d day of staying in the balloon, I suddenly felt literally as if I were rising into space, as if I already belonged to space. All sensory ties and interests binding me to the earth were literally severed, and I completely merged with the empty space above me" [171, p 130].

The feeling of "separation" or "estrangement" in certain instances was accompanied by a disorientation in space and by the development of halluzinations. It must be pointed out that one of the very first descriptions of "halluzinatory" experiences during a flight (in the literature examined by us) goes back to 1928, when a large group of pilots participated in rescuing the expedition of the dirigible "Italia" in the polar wastelands of the Arctic. The Swedish pilot Ludobor during a flight clearly saw a seated figure of a man. "This was not far from North Cape," he related, "probably Malmgren, I thought, but then it came into my head that if it were a person, he, of course, would wave something at me. I immediately descended, but the figure suddenly evaporated" [12, p 194].

The needs of practice (aviation, submarine voyages and cosmonautics) have brought to life numerous experimental research studies on animals and humans for the purpose of thoroughly studying the effect of a limiting of stimuli on the psychic state of man.

Experimental research conducted on people in this area was started by D. O. Hebb in the 1940's and on animals by I. P. Pavlov even earlier, at the start of the century, in the famous "tower of silence." A systematic study of sensory insufficiency in the interests of aviation and cosmonautics started in the 1950's.

In a number of the described experiments of foreign researchers, rigid conditions of isolation were employed, being named "strict sensory deprivation." In these experiments, the subjects were put on a bunk in a small soundproof and darkened chamber or room. Gloves or paper mittens were put on the hands for limiting tactile sensitivity. Motor activity was limited by verbal instructions in which the subject was asked to be as immobile as possible. If the chamber was not darkened and not soundproof, the subject was to put on semitransparent glasses which allowed light to pass but did not permit him to see a clear outline of articles, while earphones were put on the ears. With the earphones on, the subject constantly heard a monotonous noise ("white noise"), the intensity of which exceeded the threshold of auditory perception.

In technically more advanced experiments, the subject in a special oxygen device was submersed in water in a tank. The water temperature was kept at a constant level of +34.5°. Aside from the absence of visual (the subject was wearing a mask), auditory, olfactory, tactile and temperature sensations, the influx of stimuli from the skin and muscles was sharply reduced. This is explained by the fact that the man had no need for muscular work to resist the force of gravity.

Research on strict sensory deprivation showed that many healthy people cannot tolerate it. The experiment had to be stopped. The researchers describe a number of psychic disturbances which encompassed all spheres of psychic activity.

Very interesting were the experiments conducted in spaceship simulators. One of the pilots, during a 30-hour experiment, "saw" a television set floating in a state of weightlessness, and among the instruments of the control panel were certain unfamiliar faces. However, he tried to handle these disturbances of perception, and endeavored to look away from the TV set and the instruments. One of the pilots was engulfed by a panic fear, when the "flight" was coming to an end. Before his very eyes, the instrument panel began to "melt and drip on the floor." A third pilot during the experiment began to complain of pain in his eyes due to the hazy image on the TV screen, although the screen was completely clean, and after a 22-hour stay in the spaceship simulator, he began to shout: "It is very hot in the cabin! Take away the TV! It is becoming brown! Turn it off quickly, it is becoming as hot as the devil!" The attempts of the experimenter to convince the subject that his alarm was needless (the TV was working normally) were in vain. The subject was removed from the simulator in an extremely excited state. Upon emerging from the simulator, he said that at the end of the experiment it also seemed to him that the walls were beginning to come down over him.

In the research on sensory deprivation conducted by O. N. Kuznetsov and V. I. Lebedev, long isolation chamber experiments were used.

The research was conducted in a specially equipped isolation chamber which had equipment and instruments making it possible not only to maintain a set physiological regime, but also to constantly watch the subjects and provide objective recording of the physiological and psychological indicators.

On the basis of analyzing the experimental data, the following conclusion can be drawn: under the conditions of sensory isolation, unusual psychic states arise in man, and they initially have a functional and reversible character. It must be pointed out that they do not occur in every person. With a significant increase in the time of isolation, these functional changes become pathologic and neuropsychic illnesses (neuroses and psychoses) occur.

Psychic States Arising Under the Conditions of Sensory Deprivation

Judging from the data of foreign scientists and our research conducted jointly with O. N. Kuznetsov, under the conditions of experimental sensory deprivation, most often the researchers encountered different sensory deceptions.

According to modern notions, our sense organs are not merely windows for the involuntary receiving of information, but rather most delicate instruments for the continuous research and selection of essential phenomena in the external world. The incoming signals from the external world fall not on the "tabula rasa" of our perceptions, but rather on a ready-made program of encounter and response. The process of reflection, according to A. N. Leont'yev, is "the result not of an action, but rather an interaction, that is, the result of processes which occur in a way 'head-on.' One of them is the process of the effect on the living system, and the other is the activity of this system in relation to the affecting object" [137, p 53].

The sensory organization of man adapts in the process of vital experience to orientation under those conditions where in a majority of instances the stimuli possess a sufficiently clear informativeness for identifying them. In those instances when the informative character is insufficient for identifying them, a person, in using various methods, is able to most clearly recognize objects which affect his sense organs. Under the conditions of ecologically-closed systems, this is not always possible. As a rule, the information runs through one communications channel, and is not always sufficiently clear for complete and precise perception. In these instances, the developed and reinforced balance of the central and peripheral components of perception, if it can be so put, is disrupted as a consequence of the extreme limitation of the peripheral element of perception (sensation), and moves in the direction of the central element (conception) which has been unbalanced by sensation. The sensations which are not corrected by affirming additional signals are identified with the image of the supposed object, and lead a person to the certainty that he has accurately perceived or recognized one or another phenomenon, article, and so forth.

This type of sensory deception can be termed a recognition illusion. The following observation would be an example.

In an experiment, sounds from equipment were transmitted in a muffled manner into the isolation chamber. According to the assignment, the subject was to describe the perceived sound phenomena in the form of a report. The form of the report made it possible to compare the content of the supplied stimuli as perceived by the subject with the true one. In a number of instances, when the subject was informed of phenomena occurring outside the chamber (the conducting of electrophysiological research, the monitoring of tape recordings of reports by the service personnel, and so forth), he rather accurately and adequately perceived the noise and conversations in the control room. But with circumstances which were unclear to the subject, the noise and conversations were perceived erroneously by him. Thus, he incorrectly understood a conversation, he did not recognize a voice, and the noise of an operating electric motor in the control room was perceived by him as a tape recording of a Neapolitan song performed by Robertino Loretti. The subject was firmly convinced of the correctness of his sensations. Only upon the completion of the experiment, in discussing this state on the basis of submitted proof did he abandon his false notion.

Similar illusions have also been observed in space practice. Of interest are the observations of V. N. Volkov made during a flight on the Soyuz-7 spacecraft. "I was watching the instruments," he wrote, "when I glanced through the window at the earth flying in darkness. In my earphones was the characteristic cracking of the airwaves.... It was night on the earth below. And suddenly, out of this night, through the airspace which ignites the most refractory metals of the spaceship like matchboxes, came the barking of a dog. An ordinary dog, possibly even a simple mut.... The sound was scarcely audible, but such a unique sensation of the eternity of time and life.... I do not know where the paths of associations ran, but it struck me that this was the voice of our Layka. Perhaps it got into the ether and remained eternally the satellite of the earth. Possibly, this was the barking of other quadruped cosmonauts such as Pchelke and Mushka?... Later on (I say 'later on' although not more than several seconds passed) I began to clearly hear the crying of a child. And what voices. And again quite a terrestrial crying of a child. The universe was alive and the earth was spinning. And somewhere a child was crying on the earth. And down below there was a woman who talked to and hushed it. And a dog was barking, in protecting a home. It was impossible to understand all this. Feel it, yes" [30, pp 137-138].

The American astronaut G. Cooper has stated that during an orbital flight, in flying over Tibet, he saw houses and other structures with his naked eye. But, as calculations have shown, the resolving power of the human eye does not make it possible to distinguish such objects from such a height. American researchers have assessed this phenomenon as a halluzination which arose as a consequence of isolation and sensory starvation. Later on, in discussing this question at a Congress on Aviation and Space Medicine, they agreed with the viewpoint of Soviet scientists who feel that in the given instance this is the illusion of recognition and not a halluzination.

Eidetic notions are another form of sensory deceit also frequently encountered under the conditions of isolation.

The Soviet psychologist V. I. Myasnikov has described very vivid visual and auditory notions in a correspondent who was in an isolation chamber and was unable to judge time, since he did not have a watch and there was no fixed daily schedule. According to the instructions, at any time he wished he could lie down to sleep, eat, and so forth. Here is an excerpt from the diary of this journalist:

"Well, how do I feel? At times I am content and at times I grieve. There is a certain inner caution which is manifested in the fact that I am constantly listening.... Here, familiar melodies come to mind. Sometimes they, regardless of whether I wish it, come into my head. I hear Rachmaninoff's 'Prelude,' the music of Brahms and Ravel (the Concerto for Violin and Orchestra), and certainly the great Beethoven. For a long time I have not heard such pure Beethoven. And lying 'in the morning' too lazy to get up, in my ears I hear Beethoven's 'Ninth Symphony.' An unforgettable pleasure. In listening to Rachmaninoff..., I suddenly clearly see the entire Great Hall of the Conservatory, and even hear the voice of the woman master of ceremonies. It is even easier to hear songs, favorite arias, and romances while boring fragments from the dance verandas of resort towns swirl through my mind. They are in direct pursuit. There is one salvation from them, I begin to listen to any possible noise in the chamber and the sound of any music 'inside me' stops." But the concepts reached particular vividness when the correspondent "saw" a falling tree with a person during timber felling. "I was struck by the vividness of the notion of the sound of the operating saw and the crack of the falling tree" [40, pp 182-183].

In our experiments, eidetic concepts, in truth, not so vivid, were observed in a physician subject who thus described his sensations: "Acute moments in my life were recalled vividly and even those moments which I in ordinary life possibly would never have remembered. At times you try to escape from this, and all of a sudden there it is. For 2 days I remembered close relatives. The images of the relatives were particularly clear. I conceived them as if they were standing there and smiling." Another physician subject stated that "upon remembering you most clearly see the faces of people, more detailed, more brightly, and there are more colors, but there are no 'visions'" [107, p 167].

Eidetic concepts have also appeared in subjects under the conditions of not only individual but also group isolation. Thus, one of the participants of the year-long experiment related: "We rarely remembered the bad. If this occurred, we quickly tried to brush it aside with 'begone!' On the other hand, we retained the good in our memory, we filled out details and relived it. You are seated, thinking and writing in your diary, and suddenly you catch something good, no, an excellent memory or the mood of a single day, an hour or minute. But it has left a good mark for your entire life. And you, 'having stopped an instant,' live it again with all, as they say, your fibers, remembering, being moved and rejoicing.... Once, without having warned the people at home, I returned from a long trip. I relived the surprise of meeting, I prepared a calm appearance and quiet tone. Do we really know ourselves completely? When the door opened and I saw the amazed eyes of my wife, when her hands flew to my shoulders, honestly, I forgot the jokes and all my calmness....

"The penetrating joy of that moment has remained with me always.... And now, in compensating for the repeating terrible dream, my memory brings me back home. But the remembering has been somewhat transformed. I emerge from the chamber and see everything in detail, to the last trifle. I walk to the door and close it behind me. I walk across the square, going through the gates (steps on the asphalt, surprised nods from associates), 200 meters to the trolleybus, a half-empty bus, my stop, I get off half a kilometer to the front door, one floor, the next, and--a bell ringing.... Along the way I note things which usually I would not pay attention to such as the cherry is blooming, the neighbor's little boy is already walking by himself, without his grandmother. And in the entrance way, on the wall an inscription has survived: 'Valya+Tolya=love!' A bell ringing.... Who will open? Mother? My wife? I raise my head and there is the chamber, the fellows are busy with their books or memories, I do not know. Everything is in place...." [187, pp 41-43].

Eidetism is related to memories. Some people only imagine visual objects being recalled, while others in such instances can not only conceive them but even see what they are recalling. The remembered image is literally projected in the visual field, with the vision adapting to the perception of this image, while the face of the person assumes a certain expression of a person looking at something.

This expression is so characteristic that it is considered an indication of an actually existing eidetic capacity. Certain eidetics see the image with their eyes open, others with eyes closed, but in the latter instance the person has an impression of a perspective view of the image, and sees it at a certain distance. Visual eidetism is often found in children as well as in artists.

The appearance of eidetic representations under the conditions of sensory deprivation, in all probability, is related to a complex reorganization in the interaction dynamics of the signal (first and second, according to I. P. Pavlov) systems of reality. In an ordinary situation, the vividness of the image representations is suppressed by numerous real stimuli and the representations against this background seem pale and indistinct. But under the conditions of sensory starvation, the flow of associated representations causes vivid images which compensate for the limited and monotonous character of objects in the external world.

During one of the experiments, the physician on duty mistakenly turned on a light in the isolation chamber some 20 minutes after "lights-out." Male subject P. in the morning in his report mentioned this violation. Three days later he again reported on the turning on of the light after hours in the preceding night, although in fact this did not occur. We viewed this phenomenon as the same as a dream which was accepted by subject P. as reality.

Similar phenomena occur in an ordinary circumstance. Here is what the physiologist F. P. Mayorov writes: "Near morning, half asleep, hazily as in a fog, the notion flashed through my mind that the nurse should arrive soon. Then I fell back to sleep and saw in my dreams that the nurse had already arrived and crossed the room from the table to the closet. Having awakened and still under the impression of the vivid dream, I began to see whether in fact she was there or not. No one was there. It turned out that she had not come" [146, p 77].

The physician Kh. Ibragimov told of the following case: "Once two policemen brought to me in the polyclinic a terrified shaking man. He related that he drove a large bus. His replacement had not arrived, there were many passengers, and they persuaded him to make another trip. Upon entering the city at a high speed he had run down a column of soldiers. He went out of his mind from their shouting, he jumped off the bus and hid. The policemen confusedly shrugged their shoulders and said that no soldiers had been hit by a bus and there had been no accidents in the city...." [57, p 77]. In this instance, as in the preceding one, one can clearly trace a confusing of dreams with reality. These phenomena were termed by us "subjectively realized dreams." While under ordinary conditions a person can make certain whether or not he has been dreaming or something actually occurred, having questioned relatives, friends and others about this, under the conditions of an isolation chamber, the probability of confusing a dream with reality grows, since a person does not have any opportunity to check his doubts, even if he has them.

The entry made in the diary of subject K. substantiates this: "During the recording of physiological functions on December 24, 1330 hours, I evidently fell asleep. Later on I saw Edik come in. Could this be? Tuesday the physician Rostoslav Borisovich was on duty. I immediately asked over the intercom to say hello to Edik.... I did this to check myself" [107, p 174].

Having compared this entry in the diary after the experiment with the verbatim notes of observation, it could be established that on that day

Edik was not in the laboratory (and even if he had been, it would have been impossible for him to go into the chamber), while the recordings of the brain biocurrents at the designated time in the diary for 7 minutes showed a typical picture of sleep.

The "hypnagogic musical representations" are a unique and unusual psychic state relating to sensory deceptions. An illustration of them would be the self-observation of the physician subject S. A. Burgov under the conditions of group isolation:

"Today I would like to take up an interesting phenomenon which I have long felt at night before sleeping, but still for some reason did not note in the diary, and in the morning, naturally, forgot. Several days ago, before going to sleep I began to sense certain auditory halluzinations. Having heard them for the first time, I was frightened, and immediately schizophrenia or the splitting of a personality came to mind with the symptom of auditory halluzinations for this disease. I recalled my first patient from the psychiatric clinic of Prof Kutanin. He was a first violinist in the opera and ballet theater. And he had, along with the basic symptom of the disease--a split personality--strong auditory halluzinations. But he was a musician and a very educated one (he had completed the conservatory and graduate studies), but what about me? It was a bit disturbing.... I had just begun to fall asleep when again the music came. This time I began more attentively to listen to it. It was a somewhat mournful, rather pleasant melody (very reminiscent of Japanese music) which at one moment rose to the highest notes and then dropped to the lowest, and its character was somehow unearthly. It was reminiscent of that music which is now considered space music, or the same which is represented in the form of colors and changes in the color spectrum. But the melody was very pleasant for me. I do not recall the further course of events as I fell asleep. I did not have any dreams related to music, or more accurately, there were no dreams. I fell asleep and forgot all about this.

"The next time (a day or two later), I found these auditory halluzinations similar to organ music in a room with good acoustics. As during the first time, the music fluctuated from low to high tones. The melody was solemn and very close to my heart. At the same time its leitmotif was a light sadness possibly because it was organ music which itself is inclined to sadness and a certain mysticism. But I can say one thing that the music was very pleasant for me and caused associations which would be difficult to get across. Again there were no dreams related to the music. Another time, for me voices of a boys' choir merged with the organ music, and again melodic, high, variable and even squeaky tones....

"What was this? The fruit of a sick fantasy or objective reality transformed into music? I do not know. I can only say that all these phenomena, possibly, were related to the operating ventilator. But it is very interesting why all of this occurs before going to sleep and at night, and not during the day? Secondly, why is the character of the music heard different each time? The acoustics of the chamber? But, in my opinion, it is simply laughable to talk about this. What acoustics could there be in this crypt in the musical sense? I do not want to worry myself about this and will try to clarify everything at the end with our acoustics and psychologists together. And now I must stop, or visual hallucinations will appear if I think about all this for a long time" [107, pp 175-177].

Approximately the same phenomena were noted by Ye. Tereshchenko. In his diary he wrote: "A strange time has begun. The days, hours and minutes in some inexplicable manner have become inflated and have started to last an infinite time. We immediately felt a mortal fatigue and a strong nervous tension. Moreover, for an entire month in our absolutely soundproof chamber at night in complete stillness I have heard voices, music, the singing of Kozlovskiy, a chorus, squealing, howling, and the racket of animals in the ventilation pipe. I did not mention this to anyone. I lay with my eyes open, trying to drive off the acoustic apparitions, but nothing worked. Just before going out, Stas admitted that he had heard organ music and a boys' choir. This was why he sometimes looked so strange. He kept silent for the same considerations as I" [198, p 10].

In our opinion, the musical hypnagogic representations in the instances examined by us appeared due to the development of the ultraparadoxical phase in the period of falling asleep. With mental illnesses, this phase is continuous, but in the given observation it lasted not more than 30-40 minutes.

The next group of unusual psychic states in our experiments was composed of interpretation phenomena.

I. V. Pavlov said: "...In order to adapt to life and orient oneself in it, I must imagine definite relationships and rely on them constantly. If I have no knowledge of this relationship among things, between people and myself, then I think up imaginary ties in the place f real ones" [167a, p 414]. Above we said that the information penetrating the isolation chamber from outside, in a majority of instances does not provide an opportunity for the subjects to derive a correct notion of the events occurring outside the isolation chamber, and at the same time it attracts the attention of the subjects. The perception of stimuli with insufficiently complete information would lead not only to the appearance of various illusions, but also to interpretative phenomena reminiscent of delirious ideas.

A characteristic example of erroneous speculations as a consequence of insufficient information included in the received message is the observation made on cosmonaut K. who underwent extended solitary isolation chamber testing. On the 10th day of the testing which occurred on a Sunday, K. spoke over the intercom of the isolation chamber with the Chief Designer S. P. Korolev who at that time was in Zvezdnyy Gorodok on the occasion of the wedding of two cosmonauts. The cosmonaut knew nothing of the pending wedding as under the conditions of the experiment the transmitting of any information into the isolation chamber was prohibited. Sergey Pavlovich [Korolev], having found out that one of the cosmonauts was undergoing an isolation chamber test, went into the control room. A coworker, having turned on the intercom, told the cosmonaut that the designer S. P. Korolev wanted to speak with him. The cosmonaut noted that he was ready to talk with him, but preferred doing this out of the isolation chamber. Korolev congratulated him on the successful experiment and wished him a safe completion of the experiment. The cosmonaut thanked Korolev, and this ended the conversation.

Cosmonaut K., as we have already said, did not know why the designer was in the area of the isolation chamber, and for this reason the information was interpreted by him erroneously, although in and of itself it did not contain any false data. K. felt that a decision had been taken to immediately prepare for a new spaceflight, since the Chief Designer was even working Sunday evening. Ideas appeared on the possibility of personal involvement in the forthcoming flight. Thus, in his report after the experiment, the cosmonaut related: "The conversation led me to such ideas. In the first place, it was Sunday, and secondly, it was evening, and suddenly designer Korolev appeared in the control room of the isolation chamber. When the conversation started, I decided that that was it, and I would be released. When they said 'Sergey Pavlovich,' I had a different idea: 'This means I won't be let out. They are simply showing me off. But why is he here?' Isolation brought me to strange fantasies. I decided that evidently some immediate mission had been set for an emergency extraflight, if Korolev was here even on Sunday evening and discussing this question" [40, p 80].

The incorrectly interpreted information caused an emotional excitement in the cosmonaut which lasted until the end of the experiment and was reflected in its results.

In our opinion, this observation is a very successful model of a situation when correct but insufficiently complete information obtained under conditions excluding a possibility of clarification can be linked with random circumstances; to fantasize, proceeding from the subjective type of personality, and on this basis to create an ordered concept which in keeping with its development assumes a complete subjective apparentness. A similar, logically structured and reinforced system of notions and judgments, proceeding from which the subject begins to orient himself and plan his conduct in the experiment and after it, is externally similar to the developing paranoidal system of the type of delirium of interpretation. However, the one-sidedness of the line of argument and the failure to consider all existing circumstances in the given instance are caused by factors related not to pathophysiological disruptions of higher nervous activity, but rather by causes related to an obstacle exterior to the subject. The selectivity of the information obtained under these conditions by the subjects can be planned by the experimenter.

The following observation is also indicative on this level. In the course of the experiment in which journalist T. participated, the need arose to obtain additional information from him for solving a housing question. For this purpose, over the intercom he was asked several questions. Due to the limited influx of information, the subject became falsely convinced that the obtaining of an apartment was hopeless and based upon a subjective system of arguments worked out in detail in isolation. The conviction was so strong that even after the end of the experiment, and after receiving papers for the apartment, the keys and having been shown the apartment, the subject still viewed all this as proof of merely the "joshing" of his comrades. Of course, the creation of logical systems of interpretation is explained not only by the insufficiently complete supply of information to the isolation chamber, but also to aspects related to the particular features of the personality.

In the first place, there is the individual interest in the perceived information. The higher it is, the higher the psychic activity of the subject who thinks out the obtained information. Secondly, such individual psychological features of the personality as the absence of proper criticalness and self-criticalness, the inability to think, in selecting and comparing information with a lack of it; the inability to determine the degree of probability of the proposed hypothesis, and so forth generally predispose one to the creation of logically structured, subjectively strong systems.

The ordinary standards of behavior are most often disrupted with news about family and professional problems or unfinished business.

We can judge how sad or incomplete information of someone close can affect another person under expeditionary conditions from the diary entry of E. Bishop: "I was calmly waiting for a radiogram, looking through an old Sydney newspaper. And all of a sudden, having glanced out of the corner of my eye at Michel, I could see that he had literally fallen off his seat. It meant an important message for him and not for me! Sending.... Receiving.... Again sending...and so forth. All of this lasted more than an hour, and then Michel, swaying, with wild eyes, came out of the radio shack directly on to the deck, passing the cabin where I was. I indicated to Francis on the watch that something had happened.... 'Look what he is doing on the deck.' Francis came back immediately. 'Something is wrong with Michel, Captain. He is standing still.... It seems he is crying. I spoke with him but he did not reply.' 'Look after him, Francis. You never know with such a fellow.... An attack of the blues and into the water!.... Michel...received bad news about his wife. She was in the hospital and had undergone a severe operation. Michel found out about this from Argot (dear Argot, when I meet you, I will let you have it! Couldn't you keep this news to yourself?!)'... Soon thereafter Michel appeared and told me what had happened. It was difficult for him to speak and he was sobbing.... But this evening, he came out of the radio shack with a glowing face: 'What good fortune, Captain! I heard her voice! She is better! All is in order...' 'I am happy for you, Michel! See, you got upset in vain! Now you must smile all the time. I understand that it is difficult to be happy when your brain is swirling with a constant thought! But without the radio, Roland and Argot, you would have found out the bad news only in Chile. Even if things had gone badly, you could have lived another month without the suffering'" [16, pp 193-197]. It is difficult not to agree with this idea of E. Bishop.

Even coded stimuli of contact between the experimenter and the subject can be a source of erroneous speculation. Thus, subject B., in the course of the experiment, reported by microphone that water was not being received in

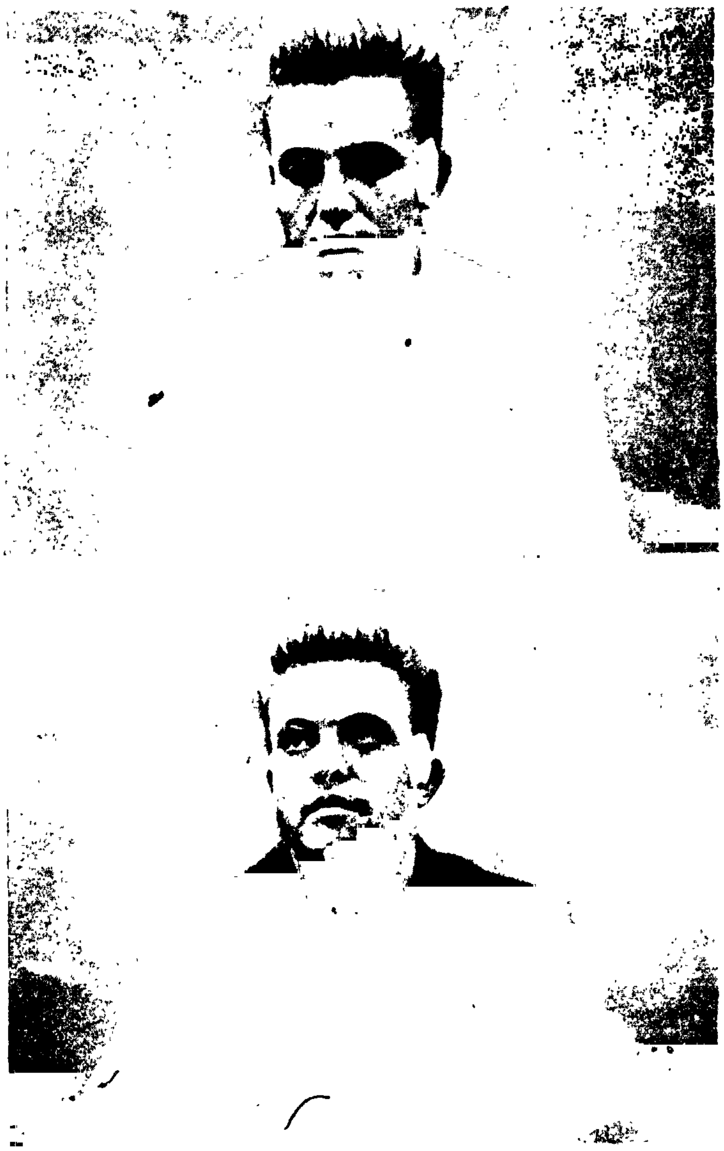

Figure 14. Subject T. During the Period of His Maximum Emotional Stress and Experiencing "the Presence of an Outsider" in the Isolation Chamber

the isolation chamber. At the same time, he had a small supply of water in the thermos. After eliminating the technical malfunction, a coded light signal was given for "there are supplies of food and water." The subject understood this signal not as information of the elimination of the malfunction, but rather as a refusal to supply water. The incorrect understanding of the information, against the background of extended isolation and the seeming inadequacy of the behavior responses in it were related, on the one hand, by the information ambiguity of the signal code, and on the other, by the individual uniqueness of the concepts which developed in the subject.

We have dwelt in detail on this problem with good reason. The experience of spaceflights indicates that in maintaining contact with the spacecraft, mistakes are made in receiving and transmitting information. The information is not always correctly interpreted. Examples of this can be found in the book by Yu. A. Gagarin and V. I. Lebedev "Psikhologiya i Kosmos" (Psychology and Space) [40].

While in an orbital flight it is possible to quickly and efficiently clarify a certain fact, in an interplanetary flight, this, in all probability, will not be so simple.

A change in self-awareness comprises the next group of unusual psychic states. In discussing one of the experiments in our research, subject T., while in the chamber, stated that on the 10th day, he had a strange and incomprehensible sensation of the "presence of an outsider" standing behind his chair. To the question: Who was this? A man or woman, an old person or a child?, T. could not answer. He was firmly convinced that there was no one in the chamber except him, but he was unable to get rid of this unpleasant and unusual feeling. He was unable to explain the reason for its development. T. also pointed out that on that day he was in a depressed mood, he was tense, and during the hours not regulated by the program, he could not find anything for himself to do. His information was substantiated by observations made on him.

The appearance of the "feeling of the presence of an outsider" in our subject can be explained by an aggravation of cutaneous sensitivity with a change in air pressure and temperature under the conditions of sensory deprivation. In a chamber, the flow of air from the chamber's ventilating system flowing over the chair of the subject could also be the source of sensations for the development of a feeling of the presence of an outsider. Changes in the air temperature and pressure perceived by the subject, with the heightening of sensitivity under the conditions of sensory deprivation, were incorrectly recognized as the presence of an outside person.

In the second chapter, we have related in detail that if the need of a person for communication with other people cannot be satisfied, then unique defense reactions of the individual appear. We would put the phenomenon of personification above all in these reactions. One of the manifestations of this phenomenon observed by us under isolation chamber conditions is the personification of the "publicness of solitude." The subject is aware that he is constantly observed by the experimenters with the aid of television and other equipment. However, he does not know precisely who is watching him at a given moment. Regardless of this, the subject endeavors to imagine a specific person in the control room, and addresses himself to him. As a rule, this person was not in the control room, and the possibility of receiving an answer was excluded. But still such a one-sided conversation with the assumed (imaginary) observer, judging from the reports of the subjects, removed their tension. They felt an emotional release and in this manner restored their neuropsychic equilibrium.

Personification arises not only under the conditions of isolation in a chamber. Judging from extensive sources in the literature, this phenomenon under the conditions of geographic or situational isolation is rather frequently manifested. Of interest from this standpoint is the note from the diary of Joshua Slocum who at the end of the last century sailed around the world alone on the yacht "Spray." "I felt alone in the endless ocean, alone in this amazing desert. Even in my sleep I understood that I was alone, and the sensation of solitude left me under no circumstances.... When I was overwhelmed by solitude, I established friendly relations with everything surrounding me and particularly with my own unimportant person" [190, p 97].

Christina Ritter who spent a polar night alone on Spitsbergen conversed aloud with the moon. She "nourished," "gave a drink" and "put to bed" the moon. In the moon she found a partner with whom she shared her thoughts and realized the noble need inherent to women of being concerned with others. Under the conditions of solitary isolation chamber research, the subjects often spoke to themselves. This occurred in the form of a dialogue, in answering questions and simultaneously replying to them. The people argued with themselves, reproached themselves, calmed themselves, explained and convinced themselves, and so forth. Here is an example of such a dialogue:

"Well, what will you be doing?..."

"Why not draw our Nina? She is constantly before my eyes. But what if the portrait is bad?"

"She might be insulted. If I begin to draw, by the start of the research I can't put on the electrodes and they will again begin to bother me."

"Let it be! Everything will be all right...."

"Get up! Get up! Lazybones! Get to work!"

"Well, all right, you talked me into it, gabby one...." [107, p 209].

We observed a unique game between the subject and himself when he questioned himself using his last name, and replied in his first name and patronymic.

In the literature we have studied, we did not find any instances showing that in group isolation, being in a normal state, a person would personify inanimate objects and converse with them in the presence of others. In all probability, if such instances were observed, a person speaking "with the wall" would be considered mentally ill. However, a majority of the researchers under expeditionary conditions have noted instances of the personification of animals. In the second chapter of our book, we quoted the episode in which the Chilean Juanito conversed with the pig called Panchita during the voyage on the raft "Tahiti Nui." (Incidentally, he did not allow this pig to be slaughtered, although the crew during the last weeks of the voyage was running short on food.) Analogous descriptions of communication with animals can be found in F. Nansen, R. Amundsen, R. Byrd and other polar explorers. Thus, C. Borchgrevink writes that when people were forced to live together for a long time, "it was difficult to avoid someone grumbling from time to time. Our sled dogs which also, possibly, had souls, did their bit for maintaining overall discipline. When human society became intolerable to someone, he headed off to his favorites, and played and romped with them. After this he inevitably returned in a better mood" [23, p 40].

According to the reports of the subjects, talking to oneself, as well as with personified partners, released emotional tension.

Of what does the psychological mechanism of a person's protective responses in talking to oneself consist?

In the "Theses on Feuerbach," K. Marx wrote that the essence of man is not an abstract inherent to an individual. In its reality, it is an aggregate of all social relations. In other words, a person, according to the views of K. Marx, can be represented as a society in miniature. "But even when," he wrote, "I became concerned with science and similar activity, activity which only in rare instances I could carry out in direct contact with others, even then I was engaged in social activity, because I was acting as a person."[1]

Consequently, if a person remains even alone with himself, he always has an interiorized (shifted inward, to the level of mental activity) audience to which he directs his thoughts and feelings.

K. Chukovskiy has noted this phenomenon in children. He asked one little girl: "For what are you crying?" "I am not crying for you," she replied. "I am crying for Mama."

The ability for interiorization appears in a person in early childhood, when imagination begins functioning in the child. In his imagination he learns to master various role functions. Thus, a young girl, in playing with a doll, in her imagination is reembodied as an adult woman, and begins to rock her doll to which she imparts particular qualities. Over time, the "interojective" images are shifted into the inner level of psychic activity. But, evidently, under the conditions of extended isolation, there is a need for their objectivation which is expressed in the personification of various objects. This process has been termed exteriorization (turning an inner action into an external one) in the words of the Soviet psychologist L. S. Vygotskiy and is clearly traceable in the physician Alan Bombar who crossed the Atlantic in a rubber boat called the "Heretic." During the voyage, he began conversing with a small doll. "The small doll," he wrote, "which was given to me as a gift by friends before leaving the Canary Islands became almost a living being for me. I looked at her and even spoke with her about everything that I intended doing. I did not wait for any replay as this still was no dialogue.

1. K. Marx and F. Engels, "Iz Rannikh Proizvedeniye" (From Early Works), Moscow, 1956, p 590.

She began to answer me later. And now I merely experience a need to speak in order to know that I exist" [19a, p 126].

If under ordinary conditions a person converses with "interojects," that is, with interiorized friends, opponents, and so forth, to himself, under the conditions of isolation, this conversation with himself begins to be expressed in the form of a verbal or written dialogue. The explanation of this mechanism, we feel, should be sought in Vygotskiy's teachings concerning the origin of higher psychic functions. "Any higher psychic function," he wrote, "was external because it was social before it became an internal intrinsically psychic function, and it was previously a social relation of two persons. The means of effect on oneself is initially a means of effect on others or on an individual" [33, p 197]. Certainly a small child, before acquiring the ability for moral behavior, was under the constant supervision of adults. His desire to violate standards was stopped by the intervention of adults, and correct actions were encouraged. Then follows a control which is based on a fear of punishment or on expectation of a reward. Self-control can be observed most clearly in a child during the stage of the appearance of speech and the development of self-awareness, that is, when he, as we have already said, acquires the ability to assume various role functions of adults in his imagination. During this period, approximately the following scene can be seen frequently. The child approaches a certain prohibited article, let us say, matches, and wants to strike one. But then, in assuming the role of the mother, and using her intonation and gestures, he says to himself: "No, no, don't touch!" Here it must be said that the struggle between the various motives of conduct in the form of an inner dialogue can often be observed also in adults. A person, conversing with a hypothetical opponent, enters various roles and tries to predict their action. For example, a general before a battle, in putting himself in the place of his opponent, in his mind begins to "play through" the enemy's possible actions vis-a-vis his own troops. Something similar occurs under the conditions of isolation, when a person talks to himself in the form of a dialogue or writes a dialogue in the same form.

The question arises of why under the conditions of isolation, in "making a partner out of himself" or in assuming various roles, a person talks with himself aloud?

Thinking expressed in the form of a verbal or written dialogue, as a form of encouraging or calming oneself, and so forth, is caused by the fact that thought, clothed in such a form, immediately assumes the character of a certain alienation, being something to a significant degree outside the individual than is a thought which is not said aloud or written down on paper. Under such conditions, the alienated word assumes a significance which it would have if it were said by another person acquainted with the experience of the individual. It turns out that thinking aloud in healthy persons is observed not only under the conditions of isolation, but also at moments of overcoming difficulties and dangers, as a form of encouragement. The psychiatrist Ye. A. Shevelev sees in this the need of a person to have support from the outside in difficult situations. Thus, when the customary forms of communication (advice, approval, sympathy, encouragement, and so forth) are excluded under the conditions of isolation, a person is forced to work out new sociopsychological mechanisms for regulating his behavior.

While in the above-given instances the "separating of a partner from oneself" is limited to the sphere of concepts and is a defensive reaction to isolation, in the instances of decompensation there is an alienation of images in the form of halluzinations, that is, there occurs a splitting of the personality which goes beyond the limits of the psychic norm. Thus, an interesting case has been described by J. Slocum. Once because of illness he was unable to sail the yacht. He tied down the wheel and lay down in the cabin. "When I came around," he wrote, "I immediately realized that the 'Spray' was tossing in a raging storm. Having looked out, I, to my amazement, discovered a short person by the wheel. He turned the handles of the wheel, gripping them with strong vice-like hands. One can understand my amazement. He was dressed like a foreign sailor, a broad red hat hung over his left ear like a cock's comb,and his face was wreathed in a thick black beard. In any other area of the world, I would have taken him for a pirate. Looking at his terrible appearance, I forgot about the storm and merely thought that the foreigner was about to slit my throat; he, it seemed, guessed my thoughts. 'Signor,' he said, 'lifting his hat, 'I do not wish to cause you any harm.' A scarcely noticeable smile played across his face, and it immediately became more pleasant. 'I am a free sailor from the crew of Columbus and am not guilty of anything except smuggling. I was the helmsman from the 'Pinta' and came to help you.... Go lie down, Signor Captain, and I will sail your ship all night....'

"I thought it must be the devil to sail under full sail, and he, literally having guessed my thoughts, exclaimed: 'There, up ahead, is the 'Pinta,' and we must catch up with her. We must sail under full sail, under full sail!'" [190, pp 67-68].

Most often with such a splitting of the personality, the ailing person shifts outside all that is alien to him, to which he relates with fear and revulsion, and against which his entire being protests. Many psychopathologists are inclined to see the development of the ultraparadoxical phase in this, when any strong excitation of one concept leads to its inhibition, and through this induces, that is, causes an excitation and intensification of the opposite concept. In the above-given observation, the dichotomy obviously occurred without the development of the ultraparadoxical phase and the exteriorized hallucinatory image presented itself to J. Slocum as a friend and assistant.

Emotional disturbances occupy a special place both with hypodynamia as well as under the conditions of sensory deprivation.

In the works of American researchers, it has been noted that sensory deprivation has a disruptive influence on work efficiency and purposefulness, and often people refuse any further remaining under the conditions of isolation.

A number of authors have noted the development of a state of depression, apathy, emotional instability, as well as the appearance of increased suggestibility. Often feelings of euphoria are noted in the subjects.[1]

Emotional disturbances under the conditions of sensory deprivation were first described in our nation by M. B. Umarov [202, 203]. The author has noted that during the first period of isolation, the subjects showed confusion and the external indications of fatigue, insomnia at night and sleepiness during the day. The subjects sang loudly, they conversed loudly with themselves, and swung their arms. In some, the euphoria was expressed in an improvement in mood, an overestimation of work efficiency and the loss of self-criticism. Here they performed actions which were prohibited in the experiment (looking into the area of the experimenter and try to speak with the physician over the intercom). The appearance of the subjects was fatigued. Increased interest in what was happening alternated with periods of sleepiness and a loss of interest in conducting the experiment. By the end of a 10-day experiment, irritability and short-temperedness appeared in the subjects. A lack of confidence in the readings of the instruments also appeared.

I. A. Maslov writes on the influence of the isolation chamber experiments on the emotional state that in some subjects by the end of the experiment, irritability had risen, they wanted to "leave the room," hit someone or "throw anything that came into hand." Others complained that at times, more often in the evening, "they were overwhelmed with sadness," and they recalled their home, relatives and friends. One subject at the end of the experiment said that there were hours when there was "stultification, thoughtlessness, and an apathy mixed with grief" [150, p 39].

Emotional disturbances have also been observed under expeditionary conditions. Thus, R. Byrd wrote about the impressions during the first expedition to the Antarctic: "One other perfidious property is found in the polar night. Antarctica is the last stronghold of inertia. On this continent, where every living thing has disappeared...inertia reigns over a vast domain. It possesses enough might to conquer anyone who does not fight it energetically; the lazy limited people very soon begin to drag out a miserable dreary existence reminiscent of a state of hibernation" [26, p 234]

In the book "Snova v Antarktike" (Back in Antarctica), this author describes a clear picture of "hibernation": "Once a fire started in the kitchen. The coal which had fallen out of the stove caught fire, and the room was filled with smoke. The men on duty, Rawson and Paine, continued to wash the dishes without concern, not showing the slightest interest in the efforts of the cook to put out the fire, although they themselves were half choked in the smoke. Rushing with great agitation around the room and operating the fire extinguisher with complete uselessness, Carbone with great excitement dashed up to the men and wanted to know if they intended to do anything?
"'That is not our job!' mumbled Rawson coldly.

1. Euphoria--a state of an elevated mood with an overtone of serene joy and bliss combined with reduced self-criticism.

"'What is not your job?' exclaimed the cook.

"'Put out fires,' explained Rawson.

"Out of amazement and indignation our cook for the first time in his life found himself at a loss for words.

"'Certainly,' affirmed Paine, lifting a keg of fresh water through the smoke. 'The kitchen crew has only to wash the dishes and set the table. The cook should do everything else. Order No 5, paragraph 1.'

"'Quite right,' added Rawson. 'Moreover, the fire was your fault.'

"By this time, the tongues of flame were crawling across the floor, and Carbone dashed across the road to the 'Palace of Science' with a call for help" [27, p 160].

An analogous picture of inhibition was observed at the end of the voyage among certain crew members on the raft "Tahiti Nui." "During that same night," related A. Burn, "during my watch it started to rain. Rejoicing, I called my comrades to help me stretch out a sail. I expected that they would immediately take part. Hans and Juanito got up unwillingly, but none of them was seemingly particularly happy over the appearance of water. I gave the helm to Juanito, and myself hurried to cover our only still operating receiver. Our fate depended on it, as without the time radio signals it was impossible to accurately determine the coordinates of the raft. In using the occasion, I decided to wake up Jean. To my amazement, Jean was not asleep, but he was not about to get up....

"Several hours later such a severe storm started that our poor raft was tossed from side to side, literally like a cork, and was splitting ominously along all the seams. I was afraid that due to the deep draft of the raft, the waves could wash overboard the box with Eric (the sick man, authors), the receiver and navigation instruments. For a long time I made no attempt to strengthen the fastenings, but when one of the beams of the middle float broke loose and threatened to break the whole frame, I forgot all fear and dove into the water. Even at such a critical moment, no one hurried to my aid. Jean and Hans looked at me in silence, and Juanito, as strange as it may seem, slept soundly, like a little child" [61, pp 171-172].

Emotional manifestations of such a sort can be observed also in the isolation chamber research. "Once," related Ye. Tereshchenko, "when I was sitting on watch, a very unpleasant odor suddenly came into the chamber. At first it was an odor and then smoke. According to the instructions on any emergency, I was to immediately report to the physician on duty. I tried to phone him. The connection didn't work! There was a fire in the chamber, but how could I tell anybody? Panic! I wanted to get out, but I could say nothing. And as if from aside and from far off I saw a person who said rather feebly: 'Is that smoke, fellows.' Was this I? Later on this person got up in order to take off the asbestos blanket. Stas moved quickly around the chamber. He sought out the source of the smoke and tried in every way to restore contact. Lenya sat quietly" [198, p 12].

In his book "God v 'Zvezdolete'" (A Year in the "Starflight"), A. N. Bozhko wrote: "I began to note in myself a certain indifference to things around me, a certain indecisiveness appeared, everything was perceived not as acutely as during the first months, you look at everything from the side, as if not a participant in the events but only an observer" [18a, p 129].

In our research there were no expressed depressions which were subjectively recognized by the subjects and which had a clear and definite objectivation, although a decline in mood accompanied by elements of tenseness and apathy was characteristic for our subjects, particularly during periods of cyclical "adaptation tension."

An example of a unique form of emotional response, against a background of lowered mood in a period of emotional tenseness during the middle of the experiment, would be our observation over subject G. In the process of the entire experiment and in the prepatory period, he excelled in punctualness and efficiency in carrying out the requirements of the experimenters. This also applied to the demands set in the preliminary instructions as well as the imposed reportings introduced in the process of the experiment.[1]

On the 6th day, having opened an envelope with a subject requiring him to describe something funny, the subject thought a little bit and categorically refused to carry out the assignment; he was tense and confused. In comparison with the usual, his motor activity was reduced. During the unscheduled time, he did not do anything. Such a state lasted 2 or 3 hours, and after this his behavior assumed the usual traits. At the end of the experiment, G. explained the reason for the refusal to carry out the "imposed reporting" as follows: "The proposal to relate something funny was so contrary to my general mood that it seemed completely inacceptable and out of place. I could not think of anything funny. Into my mind came not at all funny but rather sad thoughts and memories" [107, p 229].

That the mood of the subject was in fact rather constantly and strongly depressed was also evident in his replies to the questions in carrying out the "music-projective test"[2] during which associations of predominantly a minor character arose.

"The first fragment caused a sensation in me as if I were parting with someone near and dear, and parting forever. Associations appeared predominantly

1. "Imposed reporting"--a research method whereby the subject opens an envelope where a subject of a report is given and he must develop it creatively. The method was worked out by O. N. Kuznetsov.

2. The test consists of the following: once during the entire experiment three musical excerpts were played in the chamber, and after this the subject was instructed to answer a number of questions. The method was worked out by O. N. Kuznetsov.

of the sort that a comrade was leaving for somewhere, leaving his homeland and his friends. It was so sad for him that he sat down at the piano and what he could not express in words he got across in his music. The melody of the second fragment was sadly triumphant. There were not any associations. The third fragment seemed sad to me but at the same time pleasant. A person was sitting at the piano expressing his feelings. The third fragment seemed very much like the first. A sad and somewhat solemn situation was created by them" [107, p 230]

In the behavior of a majority of our subjects, after the halting of the extended experiments, an intensification of motor activity was observed accompanied by lively facial expression and pantomiming. Many tried eagerly to enter into verbal contact with people around. In conversation they joked a great deal and themselves laughed over their poignancy, although the situation was in no way suitable for the appearance of such gayety. In individual instances the verbal activity approached even the degree of logorrhea. In this period a great impressiveness was characteristic for the subjects. In the memories of this period even 2-4 years later, they recalled facts and details which were remembered down to the last detail and viewed as particularly pleasant and emotionally strongly colored.

In a number of instances, a "skipping" of attention was noted. Each new impression caused the forgetting of the preceding. A majority of the subjects were content with themselves, in judging the conducted experiment, although in a number of instances this was unself-critical. During the post-isolation period they did not note their mistakes in the experimental psychological research. When the experimenter pointed out the mistakes, they responded extremely indifferently, but endeavored, sometimes with great conviction, to depict their inaccurate work in the best light, and find justification for it. The state of an elevated mood and animation lasted from several hours to 2-3 days. As a rule, even when the subjects did not sleep at night due to the changed daily schedule, before leaving the isolation chamber they did not feel fatigue during the entire day and could not fall asleep for a long time at night. The following observations can serve as an example.

Subject T., on the basis of an experimental examination of higher nervous activity, could be classified in the "weak type." After the ending of isolation, he was in an excited state. He spoke a great deal on subjects not related to the experiment, he joked with persons around, without considering the situation and the mood of the others. Without having completed a conversation on one subject, he skipped to another, in being distracted by superficial associations. A coherent discussion of the conducted experiment could be obtained only on the 3d day after the end of the experiment. After the completion of the experimental psychological research, 3 hours after leaving the isolation chamber, he fled into the park which was adjacent to the experimental building. In the park he ran from one flower bed to another, from one tree to another, exclaiming aloud over what he saw, without paying any attention to the people meeting him.

Subject E. In the experimental research on higher nervous activity, he was classified in the strong unbalanced type. At the end of the experiment, increased motor and verbal activity was noted, and in conversation the skipping from one thought to another. In research on attention using the correction test method, he worked at double the speed than at the start of the experiment in the isolation chamber, but the number of mistakes increased, respectively, from six to 38. Surrounding objects made an increased emotional impression. In his report he returned repeatedly to the sensations created by the tulips which were presented to him upon coming out of the isolation chamber, exclaiming: "What beautiful tulips!" "Such vivid and fresh flowers!" "I have never been so happy and never seen such vivid tulips!" and so forth.

The report of the subject was sharply emotional and graphic, but not sufficiently logical and systematized. In his narration the isolation chamber experiment appeared very gay and intriguing, although in fact during the experiment extended periods of a low mood were noted in him.

The mental state of the subjects after the isolation chamber experiment, as expressed in increased motor and verbal activeness, a certain euphoricness and other listed manifestations, differed sharply from their behavior under an ordinary situation. These states of the subjects after the isolation chamber experiments were viewed by us as a hypomaniacal syndrome.

Here we will limit ourselves to describing unusual psychic states arising under the conditions of sensory deprivation. However, in the conclusion of this section we would like to draw attention to the following very important circumstance.

Numerous observations on persons under conditions of sensory deprivation have shown that while all the unusual mental states listed in this section at first have a functional and reversible character, with an increase in the duration of exposure to this factor, they develop into reactive psychoses, hallucinoids and other forms of mental illnesses. For this reason, the problem of combating sensory deprivation during a long spaceflight assumes great urgency.

Prevention of the Effect of Sensory Deprivation on the Mental State of Man

From the given observations, it can be concluded that particular demands must be made on the selection and psychological training of specialists for work under the conditions of isolation. At the same time, prevention of the deleterious effect of sensory deprivation on the psychic state of a man during a long spaceflight cannot be limited solely to selection and psychological training. Great attention must be paid to the measures of preventing sensory deprivation during the flight. This section of the chapter is devoted to this question.

From an analysis of the reports of various polar explorers, it follows that the expedition leaders, in combating boredom and "expeditionary madness" endeavored to load down their subordinates with work as much as possible. On this question, R. Amundsen wrote about his first expedition: "A constant and full workload for each participant is an important condition for the expedition to go off smoothly in the polar ice so that all the participants work amicably in misfortune and success. Th chief must follow the fulfillment of this condition as during a long period of time it is sometimes difficult to do. However, idleness has an extremely demoralizing effect" [6, p 171].

Analogous ideas were voiced by R. Byrd. "Undoubtedly," he wrote, "there are many methods of resisting the polar night, but we seized on the simplest and most practical. Work was our best comrade, and we gave it an ally, a system. This was our weapon.... It seems to me that the absence of a definite regime was the cause of suffering for many winter expeditions" [26, pp 233-234]. In the same book, in returning to this question, R. Byrd wrote: "We were engaged in enormous work for a larger portion of the polar night, and this work had to be completed by spring, so that we had literally no time left for rest, where we could be bored! Don't forget that the people going to the south with me were remarkable people whom I selected out of a thousand" [26, p 276].

E. Bishop also wrote that during the expedition it was necessary to make sure that "there was not a single unfilled minute and that boredom did not creep in" [16, p 132].

During all the spaceflights, the cosmonauts had little free time. They were engaged in controlling the ship and its systems, in carrying out numerous scientific experiments, as well as gymnastic exercises and domestic work.

In his diary, G. T. Dobrovol'skiy on 22 June 1971 wrote: "We are constantly busy with some work on the ship, either a tank with drinking water has to be replaced or scientific equipment turned on, the ship systems have to be inspected, a daily program has to be drawn up, communications, and so forth" [63, p 117].

Even I. M. Sechenov pointed out that motor activity in a fatigued arm is restored more rapidly if the person does not just sit resting but begins to work with the other hand. Thus, the ability to shift from one activity to another is of great importance for restoring work efficiency. The enormous capacity for work of V. I. Lenin to some degree can be explained by his ability to switch, about which he wrote: "...I am well aware that the changing of reading or work, that is, from translating to reading, from writing to gymnastics, from serious reading to literature is extremely helpful."[1]

In the orbital flights, the cosmonauts switched constantly from one type of activity to another. Here is what G. T. Beregovoy writes about this aspect of a spaceflight: "Here, in the spacecraft modules, my life is completely full of active and interesting activities: unique and totally absorbing work, enormous unflagging interest in the things around, for example, in

1. V. I. Lenin, "Complete Collected Works," Vol 55, p 209.

what one sees out the windows, and finally, the virtually constant two-way contact with the earth...." [13, pp 206-207].

There is reason to assert that in an interplanetary flight, due to the limited number of crew members, each specialist will be sufficiently loaded with work.

In returning to the conditions of life in expeditions to inaccessible regions of the world, we would like to draw the reader's attention to the entry of R. Amundsen made at the end of a 3-year expedition to the Arctic on the vessel "Maude": "We never were without work to do. If anything was in short supply, it was the time to do it. Thus there was never any time left to be bored. I am in complete agreement that work is the basic foundation on which an expedition should be based, but, nevertheless, work is not everything, and the leader who thinks otherwise makes a major mistake. If he does this, work would begin to be considered a burden and not a joy, and undoubtedly the time will arrive when even the time for work seems long" [6, p 159].

As the experiments which simulate the conditions of long spaceflights indicate, work itself, although diverse but repeated day in and day out, cannot be a panacea in combating sensory deprivation and the monotony of existence.

One of the means of this struggle is the bringing of life on the interplanetary ship close in terms of character and content to the conditions of life on the earth.

Modern man living in the middle and northern latitudes spends a larger share of his time inside. "The house," writes the French architect Le Corbusier, "has two purposes. First, this is a machine for habitation, that is, a machine designed...to give us the conveniences of life and comfort. But, in addition, it is the place of our thoughts, reflections, and, finally, this place is a dwelling of beauty which brings our mind the so needed soothing" [62, p 115]. We have already spoken of the spacecraft as a machine designed to provide everything necessary for the support of human life in an interplanetary flight. But now we should take up the questions of how to make the ship a "dwelling of beauty."

On an interplanetary ship, aside from the service areas (command post, laboratories, and so forth), various living modules will be created for the physical culture and rest of the cosmonauts. The Soyuz was the first spacecraft having a dwelling module. In this module, using various devices, the deisgners were able to create interior elements which cause a sensation of light and space. Here is how V. N. Volkov describes it: "In design terms, it (the orbital compartment, authors) was made of two hemispheres connected by a cylindrical insert. At a first, rapid glance, it was reminiscent of a large chicken egg.... If one were to use terrestrial terminology, it had a 'floor,' 'ceiling' and even 'sidewalls' (the windows were located on the walls, authors). On the 'ceiling' there were lights.... The larger portion of the 'floor' was occupied by a round hatch. On one side of the orbital module there was a 'sofa' reminiscent in configuration of a segment of a circle. This was a

Figure 15. Central Command Post of the Salyut Spacecraft.
Work Area of the Commander and the Flight Engineer

place for resting as well as a sleeping place. The 'sofa' did not have a back which was replaced by the housing of the module. For this reason it would be more accurate to call the 'sofa' an 'ottoman.' Its surface was level and smooth...and opposite the 'ottoman' was a 'sideboard' of the same shape. It was set up as a work area. On it was located the control board of the orbital module.... The sidewall of the 'sideboard' had special ancillary areas in the form of individual boxes. In them was put equipment for conducting various experiments. Also on the 'sideboard' was the control board for making navigation measurements and monitoring the star sensor.... Around the entire perimeter of the orbital compartment there were two rows of metal handgrips. Their basic purpose was additional means for holding on.... The inner facing of the orbital module, and I have in mind the walls, was made of the same material as the cabin of the cosmonauts. The surface of the 'ottoman' was somewhat different in color. It was not of even tones but rather had a small meshwork. The 'floor' of the compartment was a greenish color" [30, pp 121-122].

Although in creating the living quarters it is essential to avoid excessive space, the creation of 'halls' the presence of which causes a feeling of abandonment and solitude, as well as confinement, one of the quarters of the spaceship should be large, as was the case, in particular, on the Skylab Orbital Station.

With a lack of volume in the design, the designers can widely use the ability of color to "protrude" or "recede" on a definite background. Thus, dark colors on a light background always seem receding as do cold (bluish-green) colors on a warm one (reddish-yellow). But light colors on a dark background, like warm colors on a cold one, appear to be moving closer to man and protrude forward. These phenomena were known by the architects of ancient Rome.

The phenomena of the contrast of colors were also well known to Leonardo da Vinci who wrote: "Of colors of equal whiteness, the color which is against a darker background will appear lighter, and black will appear more obscure on a background of greater whiteness. And red appears more fiery on a darker background, as do all colors which are surrounded by their direct opposites" [62, p 122]

Extensive research by Soviet and foreign scientists has indicated that in using various interior colors it is possible to raise the work efficiency of people, to neutralize the sensation of heat or cold, to lift tension, and so forth. However, one must not overestimate the degree of this factor's influence on the sensory organs and, respectively, on the tone of the human nervous system.

A powerful flow of afferent impulses with the ordinary way of life arises as a consequence of the effect of the daily and annual periodics existing on our planet. It has been established that the illumination of the earth's surface during the day changes by 300 million fold. At present, attempts are being made to simulate daily and annual periodics. Thus, V. V. Zefel'd and L. N. Mel'nikov write that "when we are in a room, the light climate really exists for us as a light flux entering through the window. For this reason, a possible variation for solving the question of a light climate is the reproduction in the interior of an enclosed space of a light climate of a room (for example, an ordinary dwelling room) using a special screen which would perform the function of an artificial window (the light source and the picture source). If a programed change of various images were carried out on such a screen and simultaneously through it the interior were illuminated with a light of the appropriate intensity and wavelength, then, probably, by such a method it would be possible to create a sufficiently diverse light and color atmosphere for man which would tell favorably upon his neuropsychic state and would help him develop a notion of time" [73, p 117].

The program of pictures for projection on the "window" could be put on color film or could be made up of a series of slides. As the experiments of L. N. Mel'nikov indicate [151], in smoothly altering the brightness of the light source coming in through such a "window," with the simultaneous projecting of colored slides with landscapes on them, for the viewers it is possible to create the illusion of the daily course of illumination and the change in the seasons. In 1968, Yu. A. Gagarin and V. I. Lebedev [40] proposed adding sound effects using the voices of birds, the chirping of crickets, and so forth. At present, special tables have been compiled for establishing the duration of each astronomic and meteorological phenomenon within the range of the days and the seasons. They reflect the precise time for the rising and setting of the sun on each day of the month, the period of twilight, as well as a number of meteorological phenomena (rain, snowfall, fog, and so forth). These tables as well as direct weather observations by meteorologists help improve the pictures corresponding to a certain hour of the day.

K. S. Stanislavskiy wrote of the effect of light and sound effects on the psychic state of man: "At first a bright sunny color was shown, and you felt happier. At the same time, offstage a symphony of sounds started up with motor vehicles, streetcar bells, factory noises, and the distant whistling of locomotives showed daytime work at its peak. Then gradually a halflight was established. It was becoming twilight. It was pleasant, quiet and slightly sad. One felt like dozing and your eyelids were heavy. Then a strong wind arose, almost a storm. The windows rattled, and the wind roared and whistled. Rain and snow beat at the windows. Everything grew quiet along with the dying light.... The street sounds stopped. The clock struck in the neighboring room. Later on someone began to play on a piano, at first loudly, and later quietly and sadly. You became melancholic. In the room evening was already coming on, lights were being turned on and the sounds of the piano died out. Later, far off, outside the windows, the tower clock struck twelve. Midnight. It was completely silent. A mouse scratched in the floor. Rarely a car horn sounded and short whistles of a steam locomotive. Finally, everything was frozen, and total silence and darkness reigned. After a certain time, the gray shadows of dawn appeared. When the first sunbeam flooded into the room, it seemed to be that I was reborn.

"V'yuntsov rejoiced most of all.

"'Better than life itself!' he assured us.

"'In real life during the day you do not notice the effect of light,' said Shustov explaining his impressions, 'but when in a few seconds, like now, all the daytime and nighttime flows of tones flash by, you feel the strength which they have over us.'

"'Your feelings change along with the light and sound: at one minute sadness, concern, or then expectation...,' was how I expressed my impressions" [194, p 230].

As for the effect of odors and their combinations on the state of man in hermetically sealed quarters, we feel that this question merits attention.

We have already said that on the ship there should be separate quarters for the crew members. The presence of a separate quarters, as V. S. Alyakrinskiy feels, will not only provide an opportunity to be alone, but will also provide the "materialization of one's individuality in making up the interior of this room. And this is of great psychological importance. A satisfaction of one's taste is always a source of positive aesthetic emotions, the presence of which, undoubtedly, helps improve the moral atmosphere of the collective" [5, p 76].

The correctness of this notion was affirmed by the experience of the polar winterers. Thus, R. Byrd in his book relates that each winterer had one or two photographs carefully hung up over his cot, and some had a calendar. In particular, in describing Clark, he wrote that he "greatly prized his corner and took every effort to make it comfortable" [26, p 249].

"Bob Davis," wrote the antarctic explorer Mario Mare, "was the first to begin to arrange his close 'living spcae.' He nailed a shelf above his cot..., and fastened a portrait of his wife over his head" [148, p 66].

During the flights on the Soyuz spacecraft, V. N. Volkov related, even long before the flights in the orbital module the cosmonauts sought out a place for prints. "We selected them according to our taste," he wrote. "To one of the handgrips we attached a frame with a portrait of V. I. Lenin. A portrait of Lenin accompanied the cosmonauts on all flights, without exception" [30, p 123]. The interior of the orbital stations of the Soyuz class also included various photographs and landscapes.

Even from the given conclusions and arguments it can be concluded that the cosmonauts should be involved ahead of time in the equipping of their living quarters with amenities. Photographs of relatives and close friends, favorite pictures, souvenirs, and so forth which will be included in the interior of the living quarters by association will cause thoughts, images and emotional experiences and this in and of itself is one of the ways for combating "sensory deprivation" under the conditions of monotony.

As was already said, an interplanetary ship will have a hothouse with various plants and these also may be placed in the working and living quarters. Undoubtedly, these "corners of living nature" will cause positive emotions.

The very tending of the plants will cause many pleasant minutes for the cosmonauts during their off hours. "We doted on our plants planted several days before the connecting of the hothouse," wrote A. N. Bozhko. "For us these delicate stems were the embodiment of living nature which had remained beyond the limits of our present existence. Now I am a firm supporter of those scientists who feel that an area of green plants will bring enormous joy to the inhabitants of space objects, and a branch of lilac in space will mean much more for a man than on the earth" [18, p 68].

To the question from the Flight Control Center for the Salyut Orbital Station: "What about the plants? Are you giving them enough moisture?" V. N. Volkov replied: "Well, the plants are our favorites. They are growing and growing. Viktor is taking care of them, and changing the conditions. They themselves are growing. There is moisture inside. Here it is impossible to irrigate as everything floats away" [183, p 99].

In one of the TV broadcasts, G. T. Dobrovol'skiy when showing the "Oasis" related: "We constantly watch these plants, and it brings us pleasure to watch them grow. Each day we glance several times into our green corner. Normal conditions have been created here for the plants. Twice a day they are fed with a special solution and are illuminated with three special lights" [183, p 115].

Music has long been used to combat monotony in the life of people. "In the course of the winter," wrote C. Borchgrevink, in describing a winter in Antarctica in 1889-1889, "we organized all sorts of amusements, and they refreshed us excellently. We had musical evenings during which each expedition member successfully competed with the music box" [23, p 107]. R. Amundsen in his book "Ekspeditsiya na 'Mod'" (The Expedition on the "Maude") writes: "At 0810 hours (in the evening, authors)...the grog and cigars were passed round, and we enjoyed ourselves to the sounds of our favorite, the gramophone" [6, p 156].

The beneficial effect of music on the emotional sphere of people has been known since ancient Greece. Pythagoras said: "Music helps greatly in the sense of health if someone uses it properly.... There are...melodies created for the passions of the soul and against despondency and inner evils. Others, in turn, are against irritation, against anger, and against any spiritual change" [9, p 130]. Hippocrates recommended various types of music to avoid anger, envy, melancholy and bad dreams.

The effect of music on the spiritual experiences of a person has been rather widely taken up in special literature, however, its effect on physiological processes has been little studied. "Undoubtedly, the effect of music is simultaneously both psychological and physiological," writes L. Stokowski in his book "Muzyka Dlya Vsekh" (Music for Everyone). "Each cell has its individual frequency of vibration. If the vibrations stop, the cell dies.... Music, possibly, is able to activate these vibrations of the cells and intensify their vitality" [74, p 102].

The importance of music under the conditions of sensory deprivation was studied by us (together with O. N. Kuznetsov) in a special experiment. The research disclosed a common pattern of a rise in the emotional and aesthetic response of the subjects to the effect of musical works.

As an illustration we will give several observations.

For one of the subjects during the isolation chamber testing, we transmitted by radio the arias of Susanin, Prince Igor, and Konchak from the operas of Glinka and Borodin. He listened calmly to these arias, having covered his face with his arms. At the end of the experiment, he related that the music evoked in him a clear picture in his mind corresponding to his understanding of one or another work. He could literally see in his mind the stage and the artists performing the arias.

Another subject, having found out that such experiments were conducted, asked to hear the refrains of Mephistopheles, Figaro and Prince Igor and a song performed by Edith Piaf.

The request of the subject was satisfied. The aria of Prince Igor made the strongest impression on him. When he heard it, his stance and facial expression changed. Tears poured down his face and this showed his profound experiences and emotions.

A more vivid response was observed in a female subject. During the concluding period of an isolation chamber experiment, unexpectedly the First Rachmaninoff Concerto for Piano and Orchestra was broadcast. Rachmaninoff was one of her favorite composers, and this we knew. From the very first notes, the subject literally froze, she stared into space, soon tears appeared in her eyes, and her breathing became deep and broken. The picture of an emotional experience was so vivid and unusual that an experienced laboratory worker, without knowing the particular features of the emotional impact of music, turned in fear to the experimenter with the words; "What are you looking at?! Stop the experiment! She is in a bad way!" At the end of the experiment, the subject wrote in her report: "The feeling was completely unusual. I felt that I was being stifled and one more minute and I would not last. In order not to break down, I began to breathe deeply. Passing in front of me were my family, my friends, all my preceding life and dreams. Actually, it was not images, but rather I was aroused by that complex gamut of feelings which depicts my attitude toward life. Later these acute feelings began to lessen, the music became pleasant and the beauty and finiteness of it calmed me" [107, p 234].

A study of the effect of music in a 70-day experiment involving group isolation was conducted by G. M. Zarakovskiy and S. L. Rysakova. These researchers selected two groups of musical works: one upon the requests of the crew members, and another which was made up of unplanned and unexpected works both in terms of form and content. The latter included works which were probably unknown to the subjects such as the Symphony for One Man by Henri and Shaffer, the Electronic Music of Usachevskiy, and so forth. The recordings of the first group could be listened to at any time, but short concert programs were made up from the works of the second group (and individual works from the first group were included in them for control). These were broadcast in the middle and at the end of the "flight" during rest. The subjects did not receive any preliminary information on the program of the concerts or the time of their performance. The response to the various musical works was recorded in the form of a recording of the exchange of opinions between the subjects as well as by questioning.

Such an unexpected concert was extremely to the liking of one of the subjects. He stated that he could not and did not want to listen to anymore elegies or pastorales, but, on the other hand, precisely such music "in which you feel a strong tension seems the most pleasant.... This is the same as wishing to see vivid, shouting colors and a revulsion for the gray-white-green tones of our chamber. We really wanted a good dance." To another the same music seemed completely intolerable and made you want to "close your ears." On the other hand, he obtained enormous satisfaction when he heard a violin solo. Finally, a third was extremely irritated by the anxious, agitated melody of the first part of the concert. He intentionally tried to escape from it, giving preference to a major solo voluntary" [71].

During the carrying out of this long experiment, a unique "musical" experiment was organized about which the subject Ye. Tereshchenko had the following to say: "At some time in the morning I tried to contact the person on duty as the earphones were dead. I understood that now we were completely cut off. Complete isolation. We looked sadly at one another, and again each sat in his corner. And all of a sudden music poured out of the loudspeaker. And what music! Whistling, shrieking, some records played backwards, crazy giggling, mumbling and howling. We could neither turn off the loudspeaker nor make the noise less. It poured over us wave after wave. And most amazingly, I did not want to plug my ears, turn off the loudspeaker, cover it with a cushion or destroy it. I suddenly felt an easing. But what about the others? And as strange as it seems, as unbelievable, the music suddenly sharply improved our mood. It distracted us" [198, p 13].

In summing up these experiments, G. M. Zarakovskiy and S. L. Rysakova wrote: "As a whole, regardless of the significant individual differences in perception, unfamiliar very unusual music each time 'agitated,' leaving no one indifferent, and remained in the memory of all the subjects as a bright spot which broke the usual monotony. This affirms the stated hypothesis that under the conditions of the extreme limitation of external impressions and fatigue, music which is completely new produces an effect of an emotional outburst, a unique release of feelings, causing ecstasy in some, and in others, although even unpleasant, at least activity" [71, p 69].

Of particular interest is the research on the effect of color and musical actions both on the general state as well as the emotional sphere of a person. By color and music, one understands an artistic synthesis of color combinations combined in a definite manner with music. The first practical attempts to achieve a synthesis of color and music are linked with the name of the outstanding Russian composer A. N. Skryabin. The possibility of realizing this idea has now appeared with the development of electronics. New basic directions can be seen in the color music, one of which presupposes an automatic "translation" of music into color using special converters, while the other is the creative transposition of a musical phrase by the composer onto color. Scientists feel that in creating the interior of enclosed spaces, music and color compositions of both directions can be utilized.

In the opinion of polar explorers, submariners, and sailors, one of the favorite types of amusements is the viewing of films. Even in those instances when the supply of films has been depleted, people under expeditionary conditions will be quite content to look at their favorite films several times.

The movies, in contrast to all other types of art, cause an "effective participation" consisting in the fact that the viewer forgets he is in the theater, and considers himself to be a participant in the events developing on the screen.

Some psychologists feel that movies of relatives and friends will have a positive emotional impact on the cosmonauts under the conditions of a long flight. During the conducting of a year-long isolation chamber experiment, about 15 days before the New Year, the subjects were carefully asked whether they longed to see their close ones and did not want to see them in a film. Two persons answered affirmatively, while a third, having reflected a bit, refused. This subject prior to the year-long experiment had participated in isolation chamber testing of varying duration, and he was firmly convinced that the emotional releases caused by the viewing of such films would be no less difficult to endure than the monotonous rhythm of existence under isolation conditions.

Here is how A. N. Bozhko related his experiences in viewing the film: "When the lights went out in the compartment and dear faces appeared on the screen, we sat holding our breath. Boris saw his mother, wife and daughter. And I saw my relatives. They were sitting at a holiday table and raised a glass to our health. We were all deeply touched.... We saw the film several more times and we could have done it endlessly" [18a, p 47].

Subsequently, B. Ulybyshev and A. Bozhko admitted that the excitement experienced by them during the viewing of the film and the joy of seeing smiling, conversing and moving dear ones were unnoticeably replaced by a state of some depression, the again present melancholy, and the unhappy thought of the 300 remaining days until the end of the experiment.

In conducting a 70-day experiment, G. M. Zarakovskiy and S. L. Rysakova showed fragments from a "horror film" which the subjects had not seen previously [71]. Here is what Ye. Tereshchenko wrote in his diary: "On the following day, a horror film was shown on the wall of the chamber. Two women drowned a man in a bathtub, they carried him in a basket to the river and threw him in the water. But at night, the dead man was again back in the bathtub, he got up out of the water in front of the terrified women and plucked out his eyes" [198, p 13]. While ordinarily these films evoked fear or loathing in the viewers, under the conditions of protracted isolation they evoked only laughter in the subjects. "Such a paradoxical reaction," write Zarakovskiy and Rysakova, "is explained, evidently, by the fact that the actual difficulties of the experiment were incomparably more significant for the subjects than the events shown on the screen. This again shows how carefully and thoroughly one must assess the character and strength of impact of the movies. The toning effect of the surprise, however, in the given instance was very significant: the depressive mood of the subjects was definitely lifted" [71, pp 69-70].

The authors conclude that in a protracted spaceflight, it is advisable to show the cosmonauts unfamiliar and eccentric films as well as amusing musical revues.

In considering the rapid development of technology, it may be assumed that not films but rather videotapes will be used on board the craft. And still a completely distinct role will be given to two-way radiocommunications and television in combating sensory deprivation.

I. D. Papanin in his diary repeatedly noted the beneficial effect of radio conversations on the mood of the polar explorers who were spending the winter on the ice: "At 0700 hours we were called from Rudol'f Island.... We could hear very well. We were told that articles and photographs had been published in the newspapers and what was being said in Moscow about our expedition. Later on the most interesting essays, correspondence and articles were read. Upon our request, they read the page of small information comments from PRAVDA. All of this caused great excitement in us, and served as the subject for infinite lively talks. We also listened to gramophone records shipped in from Moscow. We took off the earphones moved. It was literally as if we had been on the earth.... No matter how busy we were with our affairs, we still wanted to chat with friends and hear their voices. You immediately take heart.... Then our comrades transmitted specially recorded gramophone records to us by the telegraph" [170, pp 68, 69].

Here is how L. Sil'vestrov described his experiences during radiotelephone conversations during a winter in the settlement of Mirnyy (Antarctica): "It was my turn. I put on the earphones and through the unimaginable cracking and whistling heard the unexpectedly loud but absolutely unintelligible voice of my wife. Judging from her intonation, she was mad at me for some reason, probably because I made her wait a long time at the radio bureau. It seemed quite unlikely to me that through all this noise she could hear me. But evidently she heard me even worse than I heard her, and we had to repeat each sentence several times. And thus we spoke, in part catching the sense and in part replying blindly. In essence, it was unimportant what we said, as we could write everything in a radiogram, rather the important thing was to hear the live and real voice of a close person. I left the radio operators slightly stunned and shaken by the experienced miracle. In my mind I understood that our 5-kilowatt transmitter was nothing to write home about as an achievement of technology, but somewhere in my subconscious I was firmly convinced that it was sheer magic and witchcraft to talk with a person at the other end of the world" [188, pp 59-60].

All cosmonauts who have been in space have noted the positive effect of two-way radiocommunication on the mood during the flight. G. T. Beregovoy has written: "All radiograms had a strictly immediate bearing on the fulfillment of the flight program. But during those rare moments when a lull occurred in our work, there was nothing more to the point than a friendly word from the earth or a joke. Work is work, but an emotional tie with the ground at times is simply essential for the cosmonaut. Whatever might be said, the space routes run across devilishly empty areas" [13, pp 199-200].

In his diary on 26 June 1971, during the flight on the Salyut station, V. N. Volkov wrote: "The 21st day of the flight has passed. 'Dawn' congratulated us on the setting of a new world record for remaining in space. How pleasant these congratulations are, particularly here, in space. We were touched to tears" [31, p 137].

The crew of the Soyuz-9 spacecraft was the first to take chess into space. On 10 June 1970, the first "space-earth" chess match was held. The crew of the spaceship (A. G. Nikolayev and V. I. Sevast'yanov) played in this match as one side, and Col Gen N. P. Kamanin and cosmonaut V. Gorbatko made up the "earth" team. The match started on the 141st orbit and ended in the 35th move with a draw. During the game, both sides were somewhat excited. The chess match was viewed by the cosmonauts as good active recreation. In the opinion of the specialists, the game made it possible to tone the work of the central nervous system, since this was an activity of a completely different sort than the one which occupied the cosmonauts all the days.

In the book "Puteshestviye za Tridevyat' Zemel'" (Journey to the Ends of the Earth), P. D. Astapenko gave a scene from the life of the polar workers: "One evening, our station (Little America, authors) was turned into Monte Carlo, and all the persons off work played roulette, dice, cards and other similar games in the clubroom which had been prepared for this purpose, and where a 'bank' had been set up, a 'charity desk,' and, of course, there was the buffet. The chaplain ran the 'charity desk.' He gave out nonreturnable loans to the gamblers who had lost everything. For this day, special 'money' had been printed up on the mimeograph. Such amusements served as recreation for a majority of the winterers who felt a need to distract themselves from the monotonous life during the long months of the polar night" [10, pp 70-71].

The need for emotional experiences also finds its satisfaction in the organizing of amateur activities. Here is what Yu. A. Senkevich writes: "Yes, it was becoming tedious, and we amused each other as we could. The day before yesterday, for example, Georges and Santiago organized an amateur concert for us, they sang and danced the cancan in sailor shirts, tall and stocky, like Pat and Patachon, and we doubled up in laughter. Generally there is almost always music on board the 'Ra.' Thor made up songs about flying fish, and he looked thoughtful and aloof. After Thor came Norman playing his harmonica and a not very wide repertoire, just two or three cowboy songs, and we already knew them by heart. But all these amusements were much more pleasant than the old radio receiver of Abdullah's, and he drove us to destruction with his syrupy eastern melodies" [185, pp 58-59].

There has also been amateur music in space. The U.S. astronauts Schirra and Stafford who during a flight played harmonicas even became honorary members of the American Federation of Musicians. In a decision approved by the Federation, it was pointed out that they "had carried music to previously unprecedented heights."

There was an interesting episode on the Salyut-3 orbital station. "I was filming with the camera," said P. R. Popovich, "looking through the viewer, and suddenly there was something absurd in the lens. I lowered the camera, and saw Artyukhin as he floated in from the neighboring compartment riding ...the vacuum cleaner! The flight engineer in cleaning up the quarters had sat on the vacuum and was riding it like a horseman." This "ride" made both cosmonauts laugh for several minutes and brought a unique lessening of tension.

The leadership of the year-long isolation chamber experiment on 31 December decided to send into the chamber through the hatch a small Christmas tree with a selection of toys. Here is what the subjects said about this: "This unexpected present was welcomed with excitement. We were as happy as kids. Immediately we could smell the pines and the forest, and we could literally feel the frosty breath of a winter morning. And our mood changed for the better. After lunch we did not lie down but began to decorate the tree. For the first time we felt the approach of the holidays. The toys were hung on carefully, we consulted with one another on how to do this better, and then photographed the scene, and could not get enough of it.... How grateful we were to those who remained on the earth!" [187, pp 59-60].

The birthday of V. I. Patsayev was celebrated in a unique way on the Salyut orbital station. Early in the morning of 19 June 1971, the earth warmly congratulated him on his birthday. "Thank you, many thanks to everyone," replied Viktor Ivanovich. "And what do you have for your birthday table?" asked the earth. "Canned veal, juice in tubes, tongue, Russian cheese, cottage cheese, candied fruit, and prunes with walnuts. The table is bounteous, but the customary onion, cut into three, after a long stay in space provides inexplicable pleasure. Please say thanks to everyone for the congratulations. We always feel the support of our friends and comrades, and always know that they are with us. All the best to you," he said in ending the transmission [183, p 99].

Experimental work conducted abroad for the purpose of studying the effect of artistic literature on the emotional state of people under the conditions of isolation has shown that humorous and satirical works have a beneficial effect, as well as romantic and adventure stories.

On board the Salyut orbital station, there was a library the books of which had been specially made. (In comparison with ordinary ones, they had a compressed shape.) G. T. Dobrovol'skiy in his diary on 22 June 1971 wrote: "Vadim during his free time floats about with a small volume of Pushkin or Lermontov" [63, p 117]. In the diary of V. N. Volkov on 26 June, we find the following entry: "Yesterday I even decided to read a bit of 'Eugene Onegin' before going to sleep, and was so involved that I read a whole hour after taps" [31, p 139].

During the expedition on the ship "Maude," R. Amundsen said: "I know only one occupation which I never get enough of, and that is reading" [6, p 159].

G. M. Zarakovskiy and S. L. Rysakova feel that artistic literature for a "space library" should contain: a timely detective story which totally absorbs the reader's attention; a science fiction tale which is intriguing in its originality of scientific and technical ideas and newness of the situation; a historical biographic novel which satisfies the need of a person to understand the new and at the same time provides an example for imitation; a psychological novel or tale touching on modern problems; finally, a collection of humorous tales. Naturally, in selecting the specific works, one should consider first of all the wishes of the future crew members preparing for the long flight.

Our observations show that the unusual psychic states under the conditions of sensory deprivation, as a rule, appeared in those subjects who were unable to find something to do during the hours when they were not carrying out the program. This fact shows that for combating the undesirable consequences of sensory and information "starvation" in a long flight, a cosmonaut should learn to spend his time in an interesting way, resist boredom and not become involved in "investigating" himself.

During experiments in the isolation chamber, the cosmonauts and subjects worked according to a certain program which took up 4 hours a day. During the remaining time they were left to themselves. And while the first cosmonauts (Yu. A. Gagarin, G. S. Titov, A. G. Nikolayev and P. R. Popovich) were permitted to use books, the cosmonauts in the subsequent experiments were deprived of this right. They had only sets of colored pencils and paper, and were given the task of finding the most interesting method of spending their free time.

Before the experiment, many subjects doubted their ability to productively utilize free time. During the first days they became familiar with the situation in the isolation chamber, they repeatedly studied the instructions and at times sat without doing anything, deep in thought. Beginning with the 2d-3d day, the subjects usually began to be engaged very actively in some undertaking. This activity was diverse and closely related to the individual features of each man's psychology. For example, G. S. Titov in the isolation chamber read the verses of his favorite poets aloud, P. R. Popovich sang Ukrainian songs and A. A. Leonov drew landscapes.

As is known, artists during their creativity love silence and solitude. Experimental silence in and of itself "inclined" our subjects to creativity. Here is how one of them described his "game of imagination" in his report: "During the first night, I noted certain, I would say, romantic images. In particular, from the cot in the upper mirror I clearly imagined a viewing window, such a black oval. In it were two openings in which two eyes shone (from below small crescents of light). We were being watched by a mask with eyes. The eyes glowed slightly. 'Phantomas' or, more probably, not 'Phantomas' but something closer to Russian folklore...." [107, p 148].

Certain subjects began "seeing" fantastic beasts in napkins and pieces of cotton. In using pieces of wire from the electrophysiological pickups which were no longer usable, they began to make various toys. Having noticed this, we began to "scatter" wooden blocks or convoluted tree roots in the isolation chamber before the start of the experiment. Here is an excerpt from the diary of one of the subjects: "During the first days this root did not evoke any emotions in me. But when I began to look at it on the 3d day of the experiment, it seemed very funny to me. In my imagination I began to sketch certain animals which were hidden in the wood. But just what sort of animals I was not clearly aware. After some time I clearly saw two monkeys which were pursuing an evil dragon and a large cat. Possibly, a panther or lynx. The entire composition came into my imagination on its own. I saw these animals so clearly that it was no great difficulty for me to 'release' them with a knife" [107, p 49].

The cosmonaut G. T. Beregovoy during testing of neuropsychic stability in an isolation chamber carved an airplane model from the wood. "According to the schedule," he wrote in his diary, "it is now free time, my personal time. I took up a piece of limewood and began to carve it. I wanted to carve a small YaK-3 from the piece of wood. I knew this aircraft well as at one time I had flown a good deal on it.... With a knife I carved the soft pliable lime and thought about my future. Today for me it is linked with space. I want to ascend to its bottomless depths and I believe that I will achieve this. And then, my past will also come with me into space. Precisely it has brought me here, to the isolation chamber, where I carve the lime and do battle against solitude, silence and sensory deprivation...." [13, p 10].

Certain subjects expressed their experiences in creativity. Their literary works and diary entries are evidence of the need for self-analysis and a unique psychic release under the conditions of solitude. Here is what L. S. Vygotskiy wrote about this: "Art is a necessary release of nervous energy and a complex procedure for balancing the organism and the environment during critical moments of our behavior. Only during criticl points of our path do we turn to art, and this makes it possible for us to understand why the formula proposed by us discloses art precisely as a creative act" [34, p 315].

As an illustration, we will give a fragment from a story written by one of the subjects entitled "About How I Live in the Isolation Chamber." "This was not a journey. I would rather call it an adventure. This note (I would humorously call it a story) is not as interesting and intriguing as such works as 'They Came From Far' by /Hvat/, 'Magellan' by Stefan Zweig or 'Thirty Years Among the Indians' by Turner. Still it should be curious for you to learn about the world of the isolation chamber and the experiences of a person in it. I am no hero but just a person like you. I am writing these lines in the isolation chamber at the start of the 4th day. Possibly the story would be much better if it were written after the isolation chamber sitting in a chair at a desk. But I am afraid I will forget all the experiences and I am afraid of distorting reality.

"Before taking this on, I thought a great deal about this test. I had a rather good idea of the conditions in the isolation chamber. Here it is possible to live according to a regular schedule or according to a reversed schedule. The schedule sets the time by which the subject lives. The former coincides fully with astronomical time, but according to the latter it may be daytime in the outside world but nighttime in the isolation chamber. I must confess I did not want very much to live under the reversed schedule. This is merely an additional difficulty. It must be said that recently in my life there were many problems and I was hoping that the physicians would be humane. But in the last conversation, the head physician, Oleg Nikolayevich, in a categorical form stated: 'This is no health resort, and you will live according to a reversed schedule!' The sentence was final and there was no appeal.

"I collected my few belongings: a sports suit, a logarithmic rule, a pack of paper, pencils and toothpaste. I would wash using a cotton pad moistened in rosewater, and I would clean my teeth with my tongue. But still I took along one 'illegal thing,' a few dandelions which I picked literally before going into the isolation chamber. Suddenly I wanted to take a bit of spring with me. Oleg Nikolayevich saw my spring bouquet and said nothing. In truth, I do not know out of what considerations I was permitted such license. And still I was touched when they asked me what concert they should prepare for the final day" [40, p 203].

Upon emerging from the isolation chamber, many subjects and cosmonauts admitted that they did not even imagine any creative abilities which they discovered for the first time during the testing.

Under the conditions of the isolation chamber, certain subjects during their free time were engaged in scientific research and rationalizing the devices of the isolation chamber.

We feel that the rational use of all the listed means and their proper planning during an interplanetary flight will protect the cosmonauts against neuropsychic disturbances caused by the sensory and information insufficiency.

CHAPTER VI: EMOTIONAL STRESS DURING A SPACEFLIGHT

Spaceflights bring amazing scientific discoveries, they acquaint us with completely new, unexpected phenomena and, naturally, cause a feeling of exultation and pride for man. At the same time, any flight entails serious dangers as it is still of an experimental character and no one can guarantee 100-percent success.

Impressions of the Pioneers

> Without "human emotions" there has never been, there is no and cannot be any human search for truth.
>
> V. I. Lenin

The pioneers of the universe for the first time in the history of mankind must encounter previously unknown phenomena of cosmic origin and see with their own eyes what previously, before the flights, could only be seen in the imagination of scientists and science fiction writers. This has usually evoked positive emotions in the cosmonauts. "Really beautiful!" said Yu. A. Gagarin when he saw our planet from the altitude of a spaceflight. He informed us that from an altitude of 300 km the illuminated surface of the earth could be seen very well. "In observing the surface of the earth," he related after the flight, "I saw clouds and their light shadows which lay on the fields, forests and the seas." The surface of the oceans seemed dark to him, with shining spots.

During his spacewalk, the picture revealed to A. A. Leonov seemed one of indescribable beauty. "The earth floated magnificently before my eyes and it seemed flat, and only the curve along the edges reminded me that it was still round. Regardless of the rather strong light filter in my helmet, I could see clouds, the mirror of the Black Sea, the coastline, the Caucasian Range and the Bay of Novorossiysk. The spacecraft hurtling over the earth was flooded by sunbeams. Great green areas, rivers and mountains could be seen. In twisting around, during one of the movements away from the ship, the unblinking stars began to float in front of my eyes against the background of the dark purple bottomless heavens which became velvet black. The view of the stars was replaced by the view of the sun. The sun was very bright and seemed to be driven into the blackness of the skies." A. A. Leonov later expressed his impressions from memory in pictures.

The crew of the Apollo-8 spacecraft was the first to see our planet from the greatest distance. When the ship had traveled 30,000 km, Borman radioed: "I see the earth, it is smaller than the window from which I am looking." Lovell added: "We can see simultaneously both Africa and Latin America. What a landscape! Incidentally, tell the inhabitants of Tierra del Fuego and South America that they should not go out without raincoats. A storm is coming up" [56, p 109].

After making the first loop around the moon, the astronaut Borman thus described his impressions of it: "The color of the surface is grayish, like an alabaster cover or dirty sand on a beach. There are no other colors. There are no deep tones and contrasts, with the exception of the regions by the terminator, where the relief elements cast greater shadows. All the craters are circular in shape. The slopes of some of them are located in terraces (up to 6-7 terraces). Many craters appear to be of meteorite origin, and a dark spot can be seen in their center.... The Sea of Abundance is not so clearly delimited as appears from the earth."

"What does the earth look like?" asked Houston. Lovell replied: "At the given moment I cannot discern any outlines on the earth. It looks like a glowing disc. The reflection of sunlight from the earth to the moon is eight fold stronger than the reflection from the moon" [56, pp 112-114].

The crew of the Apollo-11 spacecraft was the first to land on the moon. Having descended to the lunar surface, looking out the window, E. Aldrin made the first radio report from the region in which the lunar module had landed: "Around is an entire collection of gray stones of varying shape. And just stones!" Standing at the other window, N. Armstrong continued a description of the landing area: "It is a comparatively level surface with many craters from 5 to 50 feet in diameter. A series of stone ridges 20-30 feet tall. Thousands of small craters 1-2 feet in diameter. Directly in front of us are several banks 2 feet high. In the distance is a hill. It cannot be more than half a mile or a mile to it." Upon returning to the earth, N. Armstrong related: "From the lunar cabin the sky seemed black while outside the moon was illuminated with daylight and its surface was a brown color. The light on the moon possesses a strange ability to change the natural colors of objects. I am not quite clear how this occurs. If one looks with the sun in front or in back of you, the surface is brown. If the sun is off to the side, it is darker and seems very, very dark when you look at the moon straight down, particularly in the shadow. In your hands the lunar soil seems also dark--gray or black. The structure of the lunar soil is fine-grained, almost like flour, but it also has larger particles reminiscent of sand. Of course, you also come upon stones and stone fragments of different sizes. On the moon, we were like 5-year old boys in a candy shop. We didn't know where to look, there was so much to do" [56, pp 140-141].

The future cosmonauts will make the first "paths" on Mars and the other planets of the solar system. We hope that we will be witnesses of these flights.

The Emotional Reaction of Anxious Expectation

As experience shows, spaceflights cause not only positive emotions. The cosmonauts are clearly aware that any flight entails a danger for life. The probability of an emergency is present over the entire time the crew is on board the spacecraft, beginning from the moment of entering the spacecraft on the launching pad and ending with the emerging from the ship on landing. Thus, three American astronauts, V. Grissom, E. White and R. Chaffee died on 27 January 1967 in the cabin of the Apollo-1 spacecraft on the launching pad. The reason was a spark in the air of the cabin which was pure oxygen. Millions of TV viewers who were watching the training session of the astronauts saw this flash. And the command post heard the soul-rending cry: "Fire in the ship!" It was impossible to tell whose voice this was, Grissom, White or Chaffee.

On 23 April 1967, the Soyuz-1 ship piloted by V. M. Komarov went into orbit. This was the first test flight of a new spacecraft and it lasted more than 3 days. During this time, the cosmonaut completely carried out the program of scientific experiments. Upon returning to the earth, the lines of the landing parachute became entangled and the cosmonaut lost his life. Although this flight ended tragically, it was of enormous significance for subsequent spaceflights.

On 6 June 1971, the flight of the Soyuz-11 spacecraft began with a crew consisting of G. T. Dobrovol'skiy, V. N. Volkov and V. I. Patsayev. The crew docked the transport craft with the Salyut orbital scientific station and moved on board it. For the first time in the world, a long-term manned orbital station began to operate successfully, and this meant a new stage in the development of space research. The crew worked on board the orbital station around 24 days and conducted a large amount of scientific research. The flight program was completely carried out, and on 29 June at 2128 hours, Salyut and Soyuz-11 separated. Upon return to the earth, as a consequence of a malfunction in one of the ship's systems, pressure was lost and the crew perished from explosive decompression.

Having already returned to the earth after a flight, the Gemini-3 spacecraft sank upon landing. Its crew miraculously was rescued, but the ship remained on the ocean bottom. In the view of U.S. specialists, out of every 1,000 spacecraft flights with a crew (remaining an average of 24 hours in space during each flight), at least 95 catastrophes and accidents must be expected, including 50 percent on the powered leg of the flight, 25 percent during the flight and 15 percent upon returning to the earth [152, p 183]. A failure of automation occurred during the first American spaceflight on the Mercury craft, as a consequence of which astronaut Glenn had to land the ship using manual controls. In many instances, with a failure of the automatic devices, prompt intervention by the astronauts in controlling the craft and eliminating the consequences of accidents made it possible to successfully complete the flight program and save the life of the men.

In each specific instance, an accident is viewed by the cosmonaut as something unexpected, and it can catch him in any state. Also important is the fact that, having received an emergency signal, the cosmonaut is unable immediately to recognize the cause and character of the emergency. For the cosmonaut, the emergency is a coded mission which he must quickly decipher and take measures to save the ship. For this reason, an emergency situation causes great neuropsychic stress. However, not only an emergency situation causes emotional stress. The work itself on various legs of the flight, in occurring under the conditions of a shortage of time, also causes great neuropsychic tension. All of this poses a number of problems for space psychology.

Before beginning to analyze the psychic states of cosmonauts under the conditions of a shortage of time and under emergency circumstances, we should take up those subjective difficulties which a person encounters in expecting a possible accident.

Observations and self-observations indicate that the emotional experiences of cosmonauts before a flight are complicated and diverse. This is the natural desire to know the unknown, a feeling of concern, a feeling of duty and a feeling of responsibility for carrying out the mission.

Directly before the launch Yu. A. Gagarin said: "To be the first in space, to be alone in an unprecedented duel with nature--what more could one dream of? But after this I thought of that colossal responsibility which rested on me. To be the first to carry out what generations of people had dreamed of, to be the first to blaze the trail into space for mankind" [40, p 120].

The ability of a person to create "internal models" and to "play through" ahead of time future situations and his behavior in forthcoming events causes the feeling of anxious expectation. At the same time, the "playing through of a situation" is a necessary condition for successfully solving the problems confronting a man. The experiences of a person before the launch of a spacecraft have been vividly described by G. T. Beregovoy who had to "fly" a ship after the tragic death of V. M. Komarov. "We began the preparatory cycle at the controls," wrote Beregovoy. "I was aware that it would last another 2 whole hours.... Two-way communication was maintained with me, and I was being watched by television as in an isolation chamber. There, at the control center, they knew that the nervous tension of a cosmonaut rose during these minutes. It rises and will rise until the very moment when the rocket begins the irreversible process and the electronic clock is turned on. Only then, in this emotionally taut second for the cosmonaut, do his nerves, stretched to the limit, relax and a letdown occurs. Before this the flight can be aborted, but after this, there is no chance.... But this second and the nervous release related to it had not yet come. For this reason they tried to distract me, and to encourage me with a friendly word and joke.... It was unimportant whether or not this joke was successful. The important thing was that it maintained emotional contact, and the sensation was restored that the cosmonaut was not alone, that persons were concerned for him, and that he was involved with all the others in a common cause.... At the same time, they continued to carefully watch what was happening in the cabin. The nervous excitement of a cosmonaut can lead to mistakes. In such an instance he is promptly, tactfully but persistently reminded of do this and this, check that.... In a word, nerves are nerves and work is work.... 'Just like before battle,' I thought" [13, pp 189-190].

The psychic state of persons before battle was first described by the Russian psychiatrist G. Ye. Shumkov [225] who participated in the Russo-Japanese War of 1905. He wrote that before battle the soldiers became concerned, they appeared unusually nervous, and the men felt "on pins and needles" or "as if on coals." They showed increased sensitivity to ordinary and customary stimuli. They complained of their boots more than usual, or the footcloth had not been put on as should be. The men changed several times, they squirmed about as if the clothing and gear were causing them particular discomfort. Their fingers became unmanageable, the cigarette paper was torn and matches broken. The soldiers admitted that their thoughts were running wild and it was difficult to concentrate on anyone thing. External conduct, however, varied. Some men were very busy, while others, on the contrary, were restrained, and still others were totally silent. The men were constantly thirsty and sometimes they experienced chills or a sensation of heat.

Shumkov described such a state as a feeling of anxiety or the emotion of anxious expectation, distinguishing this state from the ordinary emotion of fear. "It is mere hogwash," wrote D. A. Furmanov, "that the troops are calm in battle, under fire, as if there were no emotions in the human kind. It is possible to learn to seem calm, it is possible to behave with dignity, it is possible to control oneself and not give way to the rapid development of external circumstances--this is one question. But to be calm in battle and during the minute before battle--no, this never was the case and cannot be" [209, p 87].

During the prelaunching period, in the emotional and volitional sphere of the cosmonauts, definite shifts occur analogous to the prestarting states of psychologically well-trained athletes or test pilots. The expression "they are off" which Yu. A. Gagarin said the moment the carrier rocket lifted off the launching pad at present has become the byword. That his emotions were of a sthenic (active) character was substantiated not only by the intonation of his voice and the expression on his face transmitted by television, but also by the instrument data. On the powered leg of the flight his pulse rose to 157 beats per minute. This heartbeat rate was viewed as adequate to the given moment of the flight mission.

The observations of K. Lager made on 60 experienced pilots who were training on flight simulators showed that before training the pulse rate increased from 72 to 115 beats per minute. But during a period of "blind" flight, that is, an instrument flight simulated on the trainer, in one out of three subjects, the pulse rate reached 140 per minute, and in individual pilots exceeded 190. In a flight on modern fighter aircraft in ordinary horizontal flight, for many pilots the pulse rate rises to 120 and more, and in shifting to supersonic speeds, up to 120-160 per minute with sharp increase in the respiration rate and a rise in the arterial pressure to 160 mm Hg and higher. Upon injecting the spacecraft into orbit, the emotion of anxious expectation does not disappear, it remains during the flight, but in a less expressed form than at the moment of the launch.

After the launching of an interplanetary spacecraft, it will move away rapidly from the earth, and no matter what happens, it cannot return as quickly to the earth.

In a long spaceflight, the cosmonauts will stand watch at the central command post, although the ship will be controlled automatically. It was noted that not every person is able to work productively in a state of anxious expectation. The foreign researcher R. Nordland has written the following about the loss of work efficiency in operators in such a state: "Electronic weaponry from the time of World War II required that the operator performed several operations simultaneously. At a moment of great nervous tension, in being under the threat of attack, the operator's ability to reason was disrupted. As a result a mass of major mistakes arose, and these the designer could neither anticipate nor explain. The mistakes were the result of the fact that the operator forgot to make important calculations, he made mistakes in the calculations or with a sudden change in the situation lost the ability to evaluate it clearly" [158, p 10].

Observations indicate that at modern automated power plants, there are periods of duty during which the personnel do not perform any operations and are engaged exclusively in watching and waiting for any emergency disruptions, and even such "easy" duties cause exceptionally strong nervous fatigue in the people. At the end of the shift, the operators are unable to engage in any mental activity, they sleep poorly, and irritability is sharply increased in them [196].

In the article "The Flight Fear Syndrome in Swedish Pilots," the Swedish psychoneurologist /A. Flukholm/ has written that gloomy presentiments and anxiety are subjective aspects of stress responses which arise as a response to the danger of a flight. In his opinion, an adequate response to danger in the form of anxiety is essential for preventing catastrophes, since it causes the pilot to be careful during the flight. At the same time, this anxiety can develop into a serious problem. The pilots either outrightly or in endeavoring to conceal their state and referring to indisposition, begin to experience a feeling of fear [207]. In another article entitled "Psychophysiological Stress Responses in Flight Crews," the same author has pointed out that in some pilots subjected to continuous stress situations during flights develop neurotic illnesses which are the cause of their grounding. "In principle,"/Flukholm/writes, "there are two types of responses to the stresses encountered in a flight and which can ground a pilot, namely, acute (neuroses of psychotraumatic origin) and chronic (anxious) or slowly developing reactions" [208, p 303].

The development of a neurosis related to the expectation of an accident can be illustrated by the following observation. The operator of an electric plant control board C. was a well-trained specialist, and had repeatedly handled emergency situations. However, after several years of work as an operator, he began to doubt that if an emergency arose he would be able to handle it. The primary cause of such notions was a case when another operator during an emergency was unable to handle the "problem situation," and the electric power plant had ceased operating for a certain time. His doubts began to overwhelm him not only when he was on duty but also at home. He became irritable and slept poorly. The neuropathologist diagnosed "neurasthenia." Regardless of treatment, the mental state of the patient continued to deteriorate, and he was forced to transfer to other work. Sometime later all the neurotic symptoms had completely disappeared.

We feel that the affliction related to the feeling of fear of flights in pilots or the fear of duty in the operators of power systems and other operator professions must be qualified as a "neurosis of expectation."

The "neurosis of expectation" was established and described at the start of our century by E. Krepelin. Anxious expectation, as we have already said, involves the possibility of a person to create internal models and "play through" future possible situations. As a rule, with the mastery of the situation, this anxious state is gradually eliminated, and then almost completely disappears. But in those instances when the inner "playing through" leads a person to the idea of a poor outcome or hopelessness, anxious expectation may be increased in him. The neurosis of expectation arises only in those instances when the model evoked with an unfavorable outcome, in the opinion of F. D. Gorbov, has "stuck."

Obsessiveness is a well-known phenomenon. This is a fear of closed spaces, height, depth, and so forth. If one looks closely at these types of fear, it can be concluded that generally these are all fears of an effect, that is, the fear of being immured, the fear of breaking down or not handling an emergency situation, and so forth. It is important that these fears beset a person when there is no real danger. A person is often aware of the absurdity of the fear, but is unable to overcome it. Thus, one can speak of a neurosis of expectation only when the inner model of the unfavorable outcome has not only been formed and "played through," but has also been "stuck" for a long period.

Undoubtedly, in preventing the development of the neurosis of expectation during a long spaceflight, it is essential not only to have careful selection and exclude the effect of various unfavorable factors, but also develop in the cosmonauts a confidence in the ship, and a certainty that if certain problems should arise they could be eliminated by the crew. On this question, G. T. Beregovoy has written: "Courage includes a readiness to take a risk, but is not free from the accompanying feeling of anxiety. And only knowledge, firm, strong knowledge of the equipment itself and the ensuing confidence...put the moral readiness to take a risk on a sound foundation which rests on awareness itself. If the equipment is not trusted, no courage can help. Without having confidence in success, it is difficult to count on it or to expect from oneself what is termed clean work" [13, p 186].

Psychic Activity Under the Conditions of Emotional Stress

In executing a number of maneuvers of a spacecraft, the cosmonauts must work in a state of emotional stress. One of the specific features of a cosmonaut's activities, for example, in landing the spacecraft on the earth or on another planet, is that each moment of the work is strictly subordinate to the information being received by the operator on the state of the controlled object and the external ("disturbing") environment. Under these conditions the actions of a cosmonaut can be compared with the descent of a slalom skier along the twisting path marked by flags ("gates"). The sequence of his working operations cannot be changed and pauses in descending the mountain are impossible. The skier is forced to perceive information, take decisions and realize them at a high speed imposed on him by the descent. Thus, a cosmonaut during a descent must work without pauses and stopping, at precisely the pace which is set by external circumstances. In landing a ship from orbit on the earth using manual controls, a very slight error in orientation in firing the retrorockets and the spacecraft can move into another orbit from which it would be impossible to return to the earth. Even with correctly executed but delayed attitude control, it cannot be excluded that the ship may land in unfavorable areas (in mountains, the tayga, or desert).

In the landing of Voskhod-2, it happened that one of the commands for activating the automatic attitude control did not work. The ship commander P. I. Belyayev was permitted to execute the descent under manual control. Having analyzed the situation, he oriented the ship and precisely at the designated time fired the retrorocket. In executing the maneuver, Belyayev acted coolly and confidently. Here his rich professional experience could be felt (in working as a fighter pilot, he had undergone good schooling in operator work under the conditions of emotional stress). Here is what N. Armstrong related about the landing of the Eagle module on the surface of the moon: "The day of the lunar landing lasted very long, and still we did not have a single minute of quiet. On that morning we were awakened at 0530 hours, and the landing occurred at approximately 1520 hours by Houston time.[1] The engine of the landing stage fired smoothly and precisely at the designated time. This occurred over the designated spot of the lunar surface, the western edge of Mount Marilyn. At that moment, we were flying upside down at an altitude of 50,000 feet[2] and the sighting of Mount Marilyn as well as the other navigation procedures showed that the landing could be executed relatively near the selected landing region. Soon our landing radar showed that we were now at an altitude of 37,000 feet, in strict accord with the landing program. But when we had descended to 30,000 feet, the computer began to give us trouble. If it failed, a warning light came on and a certain number flashed on. Even on the ground we had simulated various failures of this instrument and remembered the most typical of them. We had written out the more complicated instances on cards which we had fastened to the instrument panel. However, what was happening now was like none of these instances. Evidently the computer was overloaded and then we learned that

1. Or at 2320 hours Moscow time.

2. 1 foot equals 30.5 cm.

the personnel of the ground flight control center were really earning their money. They quickly analyzed the causes of the alert and stated that we could continue our descent.

"On the leg of the descent from 30,000 feet to 5,000, we were totally absorbed with the computer and checking the instruments, and for this reason could not pay proper attention to the 'terrain' orientation. And only when we had descended below 30,000 feet were we for the first time able to look out. The horizon on the moon was very close, and for this reason from such an altitude a great deal could not be seen. The only reference point which we noticed was a very large and very impressive crater known as Western, although, I must admit, at that moment we did not recognize it.

"Initially we thought to land not too far from this crater. The automatic equipment was bringing us precisely there. However, at an altitude of 1,000 feet, it was clear to us that Eagle wanted to . and on the most unsuitable place. From the left window I could clearly see the crater itself and a boulder-strewn area and some of the boulders were as big as a Volkswagen. It seemed to us that the stones were coming at us at a terrifying speed. Boss (Edwin Aldrin) at this time was watching the readings of the computer and the instruments. At an altitude of around 400 feet, it became clear that I would have to use a mixed flight control system, that is, take over the piloting of the module, while the automatic equipment was to be given the partial control of the engine. We reduced the speed of descent from 10 feet per second to approximately 3 feet.

"It would have been interesting to set down among the boulders. I am convinced that a portion of the volcanic debris from such a large crater is the lunar bedrock, and for this reason could be of great interest for the scientists. The temptation was great, but good sense won out. We crossed over the boulders, selecting a landing place somewhat further west. We had several suitable areas, but I still had not made the decision. At first glance, the area seemed good, but on approaching closer to it, it was no longer as attractive. The one on which our choice fell was the size of a large garden plot. On one side it was bordered by decent-sized craters, and on the other by an area strewn with small rocks. Whatever the case, we liked it. And here I landed the Eagle.

"During the last seconds of the descent, our engine raised a significant quantity of lunar dust which at a very high speed spread out radially, almost parallel to the moon's surface. On the earth, the dust usually hangs in the air and settles very slowly. Since there is no atmosphere on the moon, the lunar dust flies at a flat and low trajectory, leaving clear space behind it. The cloud which we stirred up in approaching the moment of landing still had not settled and quickly moved away from us. It seemed semitransparent. I could make out stones and craters through it but its very movement was distracting. The impression was as if we were landing through a rapidly drifting fog.

"In this leg of the descent, I was greatly concerned about my fuel consumption. The indicators stood almost on zero, and we were very close to an emergency aborting of the flight, and then we would have had to fire the liftoff engines in an attempt to reach an orbit. But we much more wanted, albeit safely, to land on the moon. Regardless of the fuel gage readings, after landing we still had fuel for 40 seconds. It is pleasant when, in spite of the instruments, you still have a gallon of fuel" [56, pp 137-139].

As is known, one of the frequently encountered maneuvers in space practices is the docking of spacecraft. The executing of the docking maneuver requires intense attention on the part of the cosmonauts, as well as great precision in the work and exceptional motor coordination. The closer the ship approaches the other spacecraft, the slower its relative velocity should be in order to provide a smooth docking, and at the same time it should be sufficiently great for activating the docking locks. Naturally, the ship and the docking object should be properly oriented to the docking assemblies. In executing this maneuver, the cosmonaut, in controlling his ship, at the same time watches the docking object and can even control it. At first glance, it may seem that here it is a question of that form of mental activity which is termed "switching of attention." But such an explanation of a series of mental processes in executing this maneuver cannot be considered completely satisfactory. In switching attention in executing this maneuver, the operator performs simultaneously two types of activity, and in a way he "splits." This is how G. T. Beregovoy describes the maneuver of the rendezvous of two craft in space: "According to the program, it was required to bring the ships (the Soyuz-2 and Soyuz-3, authors) ev... closer, to a distance of several meters! It was my turn to take the controls.... First of all it was essential to orient the ship in space. For this, I had several small maneuvering engines at my disposal. There are even more powerful engines for executing the maneuvers themselves. Aside from these engines there is also the landing engine. There is also the control panel with a good hundred instruments....

"The absolute velocity, that is, the orbital speed, was 28,000 km an hour. But you could not feel it at all. Even if you looked out the windows, it generally seemed that you were hanging suspended in space....The relative velocity of the ships, that is, the velocity of the maneuver itself, was slight. You also could almost not sense it. For this reason, you had to keep your eyes open, as they say. And this was true in the most literal sense of the word. You had to watch both the instruments on the panel and look out the windows. I was watching.... Moving carefully the controls.... The distance between the ships gradually declined and this meant that I was moving forward, I encreased the thrust of the maneuvering locks and the approach continued.... There it was, Soyuz-2, right next, you could touch it with your hand! I released the controls. We were flying by inertia in our own orbits. The ships, having a slight difference in speed, began to gradually move apart.... Again I took the controls, and we brought the ships together.... I felt tired. Not physically, but rather I felt a enormous inner tension and a strain on the eyes. The lion's share of the work fell on them [13, p 197-198].

From the standpoint of the physiologists, for achieving each type of split activity, the cosmonaut must keep concentration of the stimulus process in two different functional systems of the cerebral cortex in such a manner that negative induction does not spread from one point to another. The physiological mechanism of negative induction is manifested in the fact that the arising locus (the dominant) in the cortex of the brain hemispheres inhibits all other, less stable loci of excitation. In and of itself, operator activity, even with a high level of skills, requires great nervous strain. It is particularly difficult when the split operator activity comes close in terms of character. Precisely the closeness of the dominant loci under these conditions requires differentiated inhibition, and this entails enormous tension, since these dominant loci in the cerebral cortex endeavor to merge.

Obviously, this physiological mechanism can explain the great neuropsychic tension which is accompanied by significant shifts in the various systems of the organism. Thus, in executing the docking maneuver of the Gemini-11 spacecraft with the Agena target missile, the pulse of the American astronaut R. Gordon increased to 180 a minute.

An analogous emotional stress arises in pilots during a midair refueling of an aircraft. The pilots have related that the vast expanse of the skies, due to the proximity of the tanker aircraft, suddenly becomes amazingly "confined." This operation combines two types of activity: the customary piloting of the aircraft on the basis of already reinforced, firmly developed and automated skills, and the executing of an additional, relatively new and less familiar mission of fueling for the pilot. The significant predominance of the psychic direction to execute this new and, consequently, stereotypically nonreinforced activity ends up as that dominant which would tend to suppress the reinforced piloting skills and thereby cause a difficult neuropsychic state. Both in cosmonauts as well as in pilots, in executing this maneuver, significant deviations in the work of the various systems of the organism have been noted.

As research has shown, during refueling the heartbeat of pilots increases to 160-186 per minute, exceeding the initial values by 2-3 fold. The frequency of respiratory movements increases up to 35-50 per minute, and this is an increase of 2.5-3 fold in comparison with the usual. Body temperature rises by 0.7-1.2 degrees. Exceptionally high figures for the release of ascorbic acid are also noted (some 20 and 30 fold more). The production of 17-corticosteroids increased by 2-3 fold, and sometimes 5-6 in comparison with the usual data.

In addition to the autonomic reactions by the cardiovascular, respiratory and other systems, emotional tension is manifested in facial expressions and gestures, and a tendency for restrained actions appears. The well-known aviator S. I. Utochkin said about himself that he "was very tense during the flight," and so squeezed the aircraft's controls that "water ran out of them" [49, p 10].

In certain instances, as a result of the "collision" (in the terminology of I. P. Pavlov) of the dominant loci of excitation with the simultaneous execution of two close operations, short neurotic breaks occur, and in a number of instances these are the cause of a disruption in carrying out the flight mission and even a catastrophe.

Thus, on 17 January 1966, in the air over a small Spanish village, two American aircraft collided, a KC-135 tanker and a B-52 strategic bomber with four thermonuclear bombs on board. T. Shults thus describes the collision of the aircraft: "In the cockpit of the B-52, Captain Wendorf, whose left hand gripped the wheel while with the right he feverishly turned the fuel delivery valve, suddenly saw the right sheared-off tail of the tanker dropping on the cockpit window. Then he felt a powerful blow, the ship shook and began to crack. The enormous B-52 weighing over 180 tons and traveling in space at a speed of 275 miles an hour collided with the KC-135 and rammed it with the nose of its fuselage.... There was a strong, loud sound of an explosion which shook the skies of Almeria" [226, pp 38-39].

An even greater strain rests on the cosmonaut in an emergency situation. An accident is an extraordinary occurrence which is characterized by surprise and an exceptionally rapid change of the activity stereotype against the background of emotional tension. An emergency situation places maximum demands upon man, upon his nerves, and above all on such factors as mobility and the strength of the processes of excitation and inhibition. But to the degree that people differ substantially from one another in terms of the type of their higher nervous activity and professional preparedness, so their behavior also differs significantly.

Space is full of surprises. They wait for the cosmonauts during the entire flight and sometimes can demand an instantaneous assessment of the situation and the taking of a decision. An illustration of this would be the second general rehearsal for the landing on the moon, the flight of the Apollo-10 spacecraft. In a selenocentric orbit, the basic unit of the ship and the lunar module separated. The astronauts T. Stafford and E. Cernan in the lunar module simulated a liftoff from the surface of the moon. But suddenly after the landing stage had separated, the module began to turn around its longitudinal axis. To the astronauts it even seemed that they would fall on the moon. E. Cernan was caught by surprise. At this moment, the resourcefulness and courage of T. Stafford helped escape catastrophe. T. Stafford quickly took over control and stabilized the module. The gyroscopes had not failed. It turned out that a device had been activated by which radar location of the basic unit was carried out. After the separating of the landing module and the liftoff rocket, the device began to operate according to the set program. But since the basic unit with the astronaut D. Young was not in its field of "vision," it began to "feverishly fumble" about the skies. This was an error of the ground service which had prepared Apollo-10 for the flight.

Also of interest for us is the self-observation made by the pilot N. Tenitskiy of his experiences during the interception of an air target under difficult weather conditions involving the loss of power. Below we give a tape recording of his tale: "I fired the afterburner. My attention as before was on the target. A quick glance at the power unit display showed that the afterburner system was operating normally. Again I heard a sharp knock and instantaneously felt a power loss in the aircraft as I was moved forward from the back of my seat. Automatically I moved the engine controls from the "afterburner" position. It already seemed that I was aware that the engines had stopped, that I still endeavored to put on power and not lose sight of the target. After some time I realized that the engines were not working. I shifted my glance to the instruments and evaluated the situation. The thought flashed through my mind: 'The engines are not starting.... I have to catapult out.' I overcame an unpleasant feeling. I began to follow the instructions and the engines caught" [176, p 10].

This self-observation shows the high self-possession of the pilot. Here we can see a situation where an assessment of the current moment is accompanied by a naturally arising anxiety which is then suppressed by the intellectual and volitional effort of the pilot. If a person is unable to suppress the feeling of anxiety, then in his operator activities he begins to make mistakes.

The statistical processing of materials which analyze emergencies at power stations and substations in 1950-1955, according to the data of G. B. Yakushi, has shown that more than one-half of them occurs among the operators on duty and basically these are people with great experience (up to 25 years), that is, professionally well trained [232, 233].

K. M. Gurevich and V. F. Matveyev [58] have written that a number of operators at power plants under the conditions of an emergency situation make small, seemingly "unexpected" mistakes in their actions which exacerbate the existing situation. At times the operators, instead of taking measures to halt the emergency quickly and skillfully in accord with their knowledge and experience, take incorrect and even "stupid" actions. For example, one operator on duty, in restoring the system of the station in the process of eliminating the emergency, switched off one element after another and forgot to provide for the needs of the station itself. Deprived of power, the station ceased operating and all actions to eliminate the emergency were senseless.

Analogous cases are also observed in flying practice. For example, with a sudden failure of one engine of a piston aircraft, in a horizontal flight, the pilot instead of feathering the failed engine, feathered the other operating one, as a result of which both engines of the aircraft were turned off. With a sudden fire on the left wing during a flight, another pilot, instead of putting out the flames by a sharp turn or stalling to the right, executed a left turn, that is, into the fire, and the flames threatened to engulf the entire fuselage of the aircraft [217].

Most often the mistaken actions of the operators under the conditions of emotional stress are viewed as "losing one's head." This term is widely found among operators of "acute" professions, including in aviation and cosmonautics. Below we give a case of "losing one's head" described by N. Shtuchkin.

In approaching the airfield, in the cockpit of pilot Lugovoy, a red light flashed on signaling that fuel was about to run out. In essence, nothing particular had happened. It was possible to fly for another few minutes and land the aircraft. But the appearance of the light deprived the pilot of the ability to act coolly and efficiently. In coming in for the landing, he forgot to lower the landing wheels. The flight controller ordered a second approach, but the commands did not reach the conscience of the pilot, and he still tried to land. But he still had to make a second approach, since he had overflown the airfield.

At an altitude of 80-100 meters he began to make a 180-degree right turn, having decided to land in the opposite direction, but was to the left of the strip. He began to turn the aircraft and glide at an angle toward the landing strip. "I was on the airfield," wrote N. Shtuchkin, "observing this flight at first with amazement and later with ever increasing anxiety. 'What happened to him?' I thought. I had the impression that this was the first time the man had been in an aircraft, so unskillfully did he fly. The pilot did not execute the command and did not answer the questions of the controller, the wheels were up, and the aircraft was gliding somehow unnaturally, in a bank. It seemed that it was not controlled at all" [40, p 115]. Only due to the exceptional self-control, tenacity and firmness of the flight controller was it possible to save the life of the pilot.

From the positions of psychoneurology, the state of losing one's head in operators must be viewed as neurotic responses. In terms of its clinical picture, the behavior of pilot Lugovoy is reminiscent of a form of affective neurosis whereby in response to stimuli signaling mortal danger, motor calmness, anxiety and agitation come to the forefront. Excitation is expressed in dizziness, in the possibility of executing only simple automatic acts under the influence of random stimuli which fall into the field of vision. The specific set which controls the activity of a person is marked by extreme instability and easy change under the influence of the external stimuli. As A. M. Svyadoshch points out [184], in an agitated state, the development of thought processes is retarded. The establishing of complex relations between phenomena requiring analysis or speculation is disrupted. At the same time, disturbances in the autonomic nervous system appear, expressed as paleness of the face, rapid heartbeat and breathing, increased sweating, a shaking of the hands and other changes.

Acute affective reactions in operators during stress situations, in terms of their picture, may be reminiscent of the "stuporous form," when a person is seemingly frozen in place. Thus, K. M. Gurevich and V. F. Matveyev in their work describe the following case at a GES. The person on duty, having received a signal on a starting major emergency as well as information on the halting of power supply to important industrial installations, sat down in the chair and...sat totally still, without answering the telephone calls, without paying any attention to all that was occurring, and without giving any instructions. The emergency was eliminated by the interference of other workers. The operator on duty left the control room in the same silence, and went down the stairway of the plant, never to come back up. From a personal talk with him, it was established that this operator, although he was unable to move or talk, was clearly aware of the events occurring around him. This stuporous state is reminiscent of the self-observation made by the psychiatrist Beltz in 1901 during the earthquake in Tokyo. With the first jolts, he "froze" in the entranceway of a house and remained standing there until the doorman pushed him out. With completely undisturbed activity of the intellect, any emotional experience, sympathy, concern for the family, anxiety or fear disappeared. There was a feeling of a rapid flow of thought. This state was termed by Beltz as "emotional paralysis" [184, p 183].

One of the authors of this book (V. I. Lebedev) was able to learn of the following case from the actual work of TETs. During an emergency, the operator on duty S. fell dumb and was in this state during the entire period of eliminating the emergency which was stopped by the efforts of his assistants. At the end of the emergency, he was in a stuporous state and in such was brought home. He did not remember a thing of what occurred during the emergency. He only recalled that the siren had sounded and the emergency signal lights began operating.

The psychotic reactions arising in situations which threaten the life or entail serious consequences and are accompanied by stupor, a confused state of awareness or motor excitation were described by K. Z. Kleyst in 1916 under the term "psychoses of fright." Regardless of the great similarity of the above-described reactions to hysteric psychoses, he put the "psychosis of fright" into an independent category. He considered that the essential distinguishing feature of the "psychosis of fright" from hysteria was the transitional character of the mental disturbances and the favorable outcome of the illness showing the psychogenic feature of this affliction.

It must be stressed that instances of the inability to act adequately under the conditions of an emergency situation are encountered extremely rarely. As a rule, on the contrary, the operators in eliminating emergencies act energetically and with a particular upsurge in mood. We encounter a disorganization of psychic activity under stress conditions more rarely in aviation.

From the standpoint of evolutionary physiology, it can be asserted that primitive responses in the form of a stupor or motor excitation were inherent to primitive man who encountered terrible and incomprehensible natural calamities. At the basis of these reactions lies a biologically purposeful mechanism but which under the conditions of collective activity, has begun to be recognized by people as undesirable. This is caused by the fact that the development of a stupor-like state or a flight reaction in individual members of a tribe would impede the achieving of the set goals of the entire tribe. This is why the emotion of fear even in a primitive society began to be curbed by the use of moral and physical sanctions of the community.

It took several millenia during which the material conditions of life and social relations changed in order that the feeling of danger stopped not only to suppress psychic activity, but, on the contrary, simulate it. Nevertheless, under certain circumstances in individual members of modern society, the primitive mechanisms of biological defense are activated, as the given observations show. These primitive (acute and affective) reactions under the conditions of a highly developed society have begun to be viewed as neuropsychic disturbances which develop in stress situations.

A biological purpose in no way means that the individual consciously selects and shapes a pathologic response. From what has been said also it must not be concluded that in stress situations the nervous mechanisms are "activated" automatically and that the personality with its particular mental features does not play any role in selecting the form of behavior in a stress situation.

As B. M. Teplov pointed out, in traditional psychology, up to the present it is possible to encounter the assertion that fear in all instances causes negative (asthenic) emotions and reduces vital activity. "However," he writes, "fear in no way is something naturally inevitable or primary and which can be combated only by the voice of reason, habit and so forth. Danger may cause completely directly an emotional state of the sthenic type or positively colored, that is, related to a unique enjoyment and increasing activity" [197, p 264].

The fragment given below from the novel "Voyna i Mir" (War and Peace) by L. N. Tolstoy who is rightly considered a great psychologist of war substantiates this thought: "Tushin did not experience the slightest unpleasant feeling of fear, or the notion that he could be killed or severely wounded did not even enter his head. On the contrary, it became easier and easier for him.... He remembered everything, considered everything, and did everything that the best officer in his position could...." [201, p 239].

The experience of spaceflights has shown that both Soviet cosmonauts and American astronauts have successfully handled emergency situations. An example could be the flight of the American Apollo-13 which was launched from Cape Kennedy on 11 April 1970 at 2213 hours Moscow time. Its crew included the commander James Lovell, the pilot of the lunar module Fred Haise and the pilot of the basic module John Swigert. The flight was desgined for 10 days and envisaged the landing of two astronauts on the moon.

However, from the very first minutes of the flight, problems arose on the Apollo-13. On the orbital injection leg, the central engine of the second stage of the carrier rocket shut off 2 minutes sooner than the calculated time. Vibration was noted when the engines of the second and third stages were fired. While in orbit around the earth, the equipment did not provide rigid docking of the crew module with the lunar module. The astronauts had to close two locks manually.

On 13 April, when the spacecraft was more than halfway along the earth-moon leg, the astronauts shifted the ship to the so-called hybrid trajectory which brought the ship into a selenocentric orbit with fewer energy expenditures. On 14 April, at 0625 hours, an emergency signal awakened the atronauts. A tank with liquid oxygen had ruptured on the ship which was then 328,000 km away from earth. Fragments had damaged a second similar tank. And since this oxygen was used in operating the fuel cells which comprised the main source of electric energy in the basic unit of the ship as well as the life support system, the crew was in a critical situation.

From this moment there was no question of carrying out the planned flight program. All the knowledge and experience of the astronauts and the specialists of the ground services were focused on saving the crew and returning the ship to the earth. At the Mission Control Center in Houston, using computers and simulators, specialists and experienced astronauts were concerned with seeking out optimum conditions for saving electric power and oxygen. The lunar module became the "lifeboat" in the cosmic ocean for the astronauts, in their words. Two crew members moved into it through the crawl tunnel, and turned on the power unit and the life support system. The hatches in the tunnel were kept open so that oxygen would enter the crew module where the third astronaut remained.

Seemingly the immediate threat to their lives had been eliminated. However, it soon turned out that the life support system of the lunar module could not handle the absorption of carbon dioxide. In using the hoses of their spacesuits, the astronauts connected the system of the lunar module to a cartridge containing lithium hydroxide in the crew module. In escaping from one difficult situation, the crew immediately fell into another. The shortage of electric power was immediately reflected in the work of the heating system. In the crew compartment, the temperature dropped to 5 degrees.

All of this occurred when Apollo-13 was approaching the moon on the "hybrid trajectory." The most important task which immediately confronted the crew and the flight leaders was to shift the ship to a trajectory of free return. This could be done only by using the engines of the landing stage of the lunar module. However, even during the launch and in the flight, a pressure drop had been noted in the tank with helium used in the ejction system for supplying fuel to this engine.

Still on 14 April around 1200 hours it was possible to correct the trajectory and the ship, having flown around the moon at a distance of 250 km, returned to the earth. On the moon-earth leg, the crew made two other corrections in the trajectory for bringing the splash-down in the region of the Pacific. Not long before landing, the astronauts left the lunar module and moved into the basic crew module. The concluding operations of separating the engines of the module and the lunar module occurred normally. The astronauts noticed that the engine module had sustained great damage and that the entire casing had been torn off. "Complete chaos," they radioed to Mission Control.

Having lost cosmic velocity in the earth's atmosphere, the crew module landed on parachutes. This occurred on 17 April at 2108 hours in the Pacific. Thus ended the dramatic flight of Apollo-13 [135]. During this flight, th American astronauts behaved courageously and coolly and this provided th safe return to the earth.

There can be no doubt that under the conditions of emotional stress, the moral qualities of a personality and its sets are manifested, and these mobilize the person to adequately reflect the constantly changing situation under emergency conditions and to carry out the taken decisions.

It must be pointed out that during the work of man under stress situations, the role of the moral and psychological factor and the professional training of the cosmonauts should not be overestimated. One must not overlook the well-known Pavlovian understanding of the type of higher nervous activity as an aggregate of congenital and acquired qualities, of the biological and social predispositions for the development of a neurosis, as well as the basic mechanisms of a neurotic break. It is essential to clearly realize that the burden which rests on the psyche of a cosmonaut during an emergency is a burden on the functioning nerve formations which in each person have their own range of reactivity and their own limit of efficiency. Precisely this explains the fact that acute affective reactions do not develop in anywhere all the persons who are under the same unfavorable conditions, be it an emergency situation, a natural calamity or combat. At the same time, we feel, the development of a neurosis (and, in particular, affective states) in each specific instance occurs with the particular "apportionments" of events in time. We will endeavor to explain this idea by the following mechanism.

P. K. Anokhin has advanced the concept of "anticipatory reflection." "All the most minute afferent features," he writes, "of the previous results from a given action are immediately recreated in response to a conditioned stimulus, and before even the reflex action has been formed, an afferent apparatus for assessing the possible results of just the pending action is formed in advance. We have termed this unique afferent apparatus the acceptor of the action, and this means an apparatus which receives the reverse afferentation and compares it with what was the goal of the given action, and depending upon the results of this comparison, can begin the formation of a new, more accurate response" [7, p 201].

When as a result of this afferent synthesis, intentions for a[illegible]re formed and began to be realized, the appearance at this moment [illegible] unexp[illegible]d or unforeseen stimuli causes, in the expression of F. D. Gorbov, "a blo[illegible] to the system of foresight," and even in persons with a stronger s[illegible] this blow can cause the state of an affect. Here of importance [illegible] moment of carrying out the plan of actions the "tripping" occurred[illegible]

Let us turn to the observations of A. M. Svyadoshch which go back to the period of the Great Patriotic War. Male patient V., 21 years of age, prior to military service secondary schoolteacher, had been on the front since 1942. On 12 August 1943, on the 4th day of combat, in taking a population point, suddenly at the corner he collided face to face with a German soldier. V. froze with his rifle in hand. His enemy also stopped for a moment, and then quickly retreated and lowered the automatic, but V. continued to remain immobilized and did not try either to make a bayonet attack or take cover from the enemy. At this moment one of the Soviet soldiers cut down the Nazi with a shot. V. continued to remain immobilized with his rifle clutched in his hand. Comrades who ran up began to jostle him, but he did not respond to anything. It must be pointed out that this soldier had participated actively in combats generally and in the described episode (in particular, he was one of the first to break into the population point occupied by the enemy). The enemy who suddenly appeared on his path was outside the sphere of his foresight. There was a clear "blow" to the system of foresight (to the "acceptor of action") entailing the development of an affective state.

One of the self-observations can also be used to show the importance of a "blow" to the acceptor of action at an unexpected moment. We will give an excerpt from the diary of one of the authors of this book, V. I. Lebedev: "The oceangoing submarine on which I was serving, after an extended dive, surfaced and returned to its base. It would seem that all the tension related to the long cruise was now behind. The officers and sailors took turns going up to the bridge to breathe fresh air. Then it was my turn. When I went up, it was a quiet summer evening. And in this silence, like a bolt out of the blue, there came the cry: 'Mine off the bow!!' and 'Hard to starboard!' commanded the watch officer. Then I do not recall anything that happened on the bridge. I only recall that I stood enthralled and watched the mine floating nearby. I came to at the moment when one of my comrades tapped me on the shoulder." After this episode, I learned that everyone who had been on the bridge experienced an analogous state. The commander of the ship, the watch officer and the signalman did not experience such a state.

In the given observations, we would like to draw attention to the following aspect. The soldier V. had fought for 4 days in combat continuously. The episode with the mine happened after a long and difficult voyage. In both instances, evidently, asthenization of the nervous system was observed in the men to one or another degree.

In line with the possibility that operators may make mistakes in a state of "losing their head" or with their refusal to work in a state of an affect, both in human factors engineering and in space psychology, the problem of "reliability" has arisen. At present this problem is being solved by psychological selection, the task of which includes a study of not only the obvious qualities of a personality, but also its potentials and "reserves." For cosmonauts, in particular, this is the ability to work productively under the conditions of emotional stress. Not only various stands (isolation chambers and so forth) are used for disclosing this ability in the cosmonaut training system, but also emotionally full types of activity, for example, parachute jumps.

Will, quick reaction and other qualities needed in the professional activities of cosmonauts can also be developed by flights on jet aircraft. During them, persons are eliminated who are unable to work under the conditions of emotional stress. An examination of a large amount of literature on aviation psychology and psychoneurology has shown that there have been extremely few instances when affective states arose in experienced pilots during critical situations.

The emotional stability of cosmonauts preparing for a long spaceflight will be tested out not only on the ground, in parachute jumps and in jet flights, but they will also go through the "crucible" of repeated flights in near space.

CHAPTER VII: THE RHYTHM OF WORK AND REST DURING A SPACEFLIGHT

We have established that in a long spaceflight, the possibility of the failure of various technical systems or the possibility of unforeseen complications arising cannot be excluded, and these will necessitate emergency intervention by the cosmonaut. In practical terms, it is virtually inconceivable to provide for all possible deviations in the operation of working mechanisms or all malfunctions and emergency situations. Unexpected and accidental events can be handled promptly only by the rational actions of man who possesses great knowledge and experience. For this reason, the constant standing of watches by the cosmonauts will be organized at the controls of the interplanetary ship.

Immediately the question arises of how long a cosmonaut, in standing watch, can be in a state of readiness to act, or, in other words, when will he develop a fatigue which may tell unfavorably upon the quality of his operator activities? It is also essential to disclose how much time will be needed for recovering work efficiency, and how much time must be allocated for active rest, sleep, and so forth, and to the degree that each crew member will stand watch at different times, so the question arises of the altered rhythm of labor and rest in a space flight. This chapter will be devoted to these questions.

Specific Features of Standing Watch in a Spaceflight

> Aside from the strain on all the organs which perform labor, during the entire time of labor there must also be purposeful will expressed in attention, and the more will is necessary the less the labor attracts the worker in its content and method of execution.
>
> K. Marx

The activity of a cosmonaut on board an interplanetary spaceship will be different in the following ways from the usual operator work in highly automated systems, for example, at the controls of a modern power station. The cosmonaut standing watch at the central command post of an interplanetary ship should in parallel perform several functions which are related to very

C.3

distant areas of science and technology. For example, monitoring the work of the life support systems requires biological knowledge and knowledge in the area of chemistry, while monitoring the work of the power systems and flight trajectory requires engineering and navigational knowledge.

In a general form, the functions of a cosmonaut in standing watch at the controls with normal work of the automation, will consist in monitoring numerous indicators, in operations involving the monitoring of the amount of the regulated parameters of different systems, in mathematical and logical processing of information received from the instruments and signal systems, the generalizing of the monitoring results and the comparison of them with the program, and in taking decisions on controlling the object and carrying out this decision.

The profession of an operator in automated systems requires a high intensity of attention over virtually the entire extent of work activity. This requirement is caused by the fact that with the failure of any system or with the development of an emergency situation, in a number of instances the cosmonaut must immediately move from observation to action. This is why the cosmonaut at the controls should always be in a state of readiness to act, and this has been termed "operational quiet" by A. A. Ukhtomskiy. "Operational quiet," he wrote, "is a readiness to act which can be established on varying levels. The more highly organized ability for operational quiet, at the same time is a more organized, immediate readiness for action" [204, p 129]. In speaking in technical language, the operator during his duty performs the role of a "slave circuit."

Precisely the degree of readiness to act is an important factor in the reliability of man as an element of control in the "man-spaceship" system, and precisely it determines the efficiency and timeliness of intervention by the cosmonaut on duty into the course of events.

Thus, in a long interplanetary flight, with the work of automation, the duration of the monitoring watch will be limited by observing the readings of many instruments and indicators. The type of activity, when a person must merely observe the instruments which for a long period of time do not show any "disturbances" in the system, can be characterized as monotonous. However, this is not all of the matter. The cosmonaut will work in a cabin with limited room filled with steadily flashing instruments. Here his motor activity will be significantly limited. This type of working hypokinesia may be also considered a factor of monotony. Even K. Marx pointed out that "continuous monotony of the work weakens the intensity of attention and an upsurge of vital energy, since it deprives the worker of that rest and excitement which are created by the very fact of changing activity."[1]

[1]K. Marx and F. Engels, "Works," Vol 23, p 353.

Thus, the very structure of operator activity at the command post of highly automated systems includes the demand of maintaining a high level of intensity of attention and a readiness to act, and the factors influencing a reduction in these functions are included in the working conditions.

Observations have shown that in a number of instances, monotony influences not only a reduction in attention and a readiness for emergency action the appearance of tedium and sleepiness before the appearance of a strong stimulus accompanied by an affective outburst or convulsive attack. In the fifth chapter of the present book, we have analyzed certain unusual psychic states which arise under the conditions of sensory deprivation, and here we will take up the problem of the decline in the readiness to act as a consequence of developing sleep inhibition.

During the period of World War II, attention was drawn to the fact that in pilots during long night flights, unique states arose where, regardless of the danger and responsibility, the pilots experienced a sort of apathy, their attention was dulled, and an insurmountable sleepiness arose. In aviation psychology the concept of the "psychology of boredom" appeared. Aviation physicians encountered this phenomenon also in the postwar period during long daytime flights. Thus, G. A. Yefremov and Ye. A. Derevyanko noted that long flights are characterized by crew complaints of sleepiness. According to their data, in such flights on bombers, the aerial gunners (56 percent), that is, persons performing a monotonous job, complained most of sleepiness, while the pilots experienced such a state in 21 percent of the cases, and 18 percent for the navigators [135].

F. P. Kosmolinskiy writes that in the 1950s, when automation (automatic pilots and other automatic instruments) began to be used in the piloting of aircraft, instances of pilot sleepiness became more frequent, and the effect of a monotonous situation was being felt.

The development of sleep inhibition during operator activity has also been observed during spaceflights. Thus, while the Apollo-8 spacecraft was in orbit around the moon, after a session of TV communication with the earth, F. Borman and J. Lovell, having made themselves comfortable on suspended berths, fell asleep. W. Anders went on duty. The monotonous lunar landscape literally lulled him, and W. Anders fell asleep on duty [56].

The phenomena of a reduction in attention and the development of a sleepy state are observed not only in pilots and cosmonauts, but also among railway engineers, persons on duty at the controls of power stations and in other operator activities.

Thus, V. N. Pushkin has analyzed the materials of emergencies which occurred due to the fault of railroad engineers. According to his data, 61 percent of the emergencies was related to a rather sharp decline in vigilance. The author attempted to study the readiness for emergency action under conditions of monotony which simulated the work of the engineer. During a three-hour experiment, the subjects were given 30 stimuli to which they were to react by a response. The intervals of the stimuli varied from 1 to 15 minutes (thus the element of surprise was created). On the basis of the materials obtained, the researcher drew the following conclusions: 1) Attentiveness varies under the conditions of monotonous work; 2) As a rule, readiness to act in the course of the experiment did not reach 100 percent, but showed fluctuations between 45 and 65 percent. The fluctuations in the different subjects formed a more or less broad strip which could be designated as the average level of readiness for the subjects to act under the conditions of the given experiment; 3) The fluctuations in the readiness to act are interrupted at a certain moment of the experiment by a sharp decline in the vigilance curve. Such a reduction in the readiness to act was termed by the author the "critical point" [179].

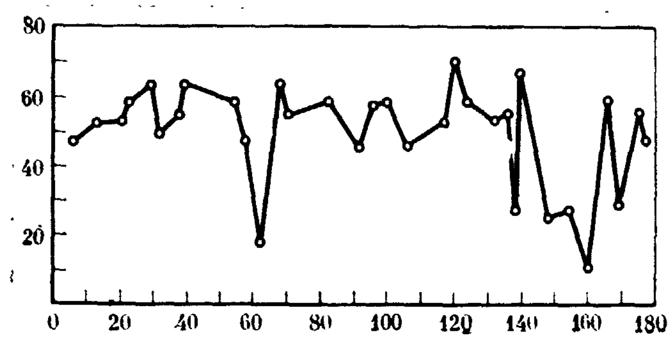

Fig. 16. Vigilance curve of the subject (at the 160th minute, one can see the "critical point" expressed in a sharp decline in vigilance)

One of the numerous graphs given in the work of V. N. Pushkin can serve as an example of such a critical point. In the diagram (Fig. 16), the basic mass of sensoromotor responses is distributed in the zone from 45 to 70 percent. This zone is the average level of readiness for the given experiment. In delivering the stimulus in the 65th minute there was the first sharp drop in the curve. The value of the readiness to act dropped from 59 percent at the 55th minute to 19 percent at the 60th minute. With the next stimulus at the 66th minute, readiness had risen to its average zone, and reached 65 percent. After this, for the next 74 minutes, the curve continued to fluctuate basically within the limits of the average-value zone. But starting with the 140th minute, it declined sharply and, having formed a shoulder showing a regular decline, reached 10 percent by the 160th minute. This is the critical point of the given experiment.

"The value of the critical point for professions requiring increased attentiveness (a railway engineer, operator, and so forth)," writes Pushkin, "consists in the fact that it is an internal factor for the possibility of an accident. If the emergency situation arises at the moment when the worker's vigilance is at the lowest point, then he is unable to promptly take measures and thereby does not prevent the emergency situation from developing into a serious accident" [179, p 182]. Of the 61 percent of the emergencies which occurred due to the loss of attentiveness by the engineers, according to the data of this author, 4 percent involved an absolute loss of attentiveness related to the development of a state of sleep. The remaining 57 percent of the accidents were related to a relatively sharp decline in vigilance. It is essential to stress that the critical point was discovered by Pushkin in 78 percent of all the experiments, and, consequently, it is a phenomenon characterizing the specific dynamics of readiness to act under monotonous conditions.

The subjective experiences of the subjects during the moment of the critical point were compared with the reports of engineers who had accidents as a consequence of the loss of attentiveness. Thus, in subject D, the readiness to act varied within the zone of 40-70 percent. From the 140th minute, it began to drop sharply, and reached 8 percent by the 154th minute. Subject D, in answering the question of his state during the experiment, said that he "was lost in thought," and "when the light went on, I could not collect my thoughts immediately and for this reason tripped the switch slowly." This self-observation of the subject in the experiment was compared with the explanation of an engineer who had an accident. "The speed was 15 kilometers per hour," he wrote in his explanatory report, "I was growing numb, my eyes were closed and I received the signal when I was 30 meters away from the cars, I braked, but the cars were close..." [179, p 183]. Such paroxysms[1] of the shutting off of consciousness during operator activity require the carrying out of differential diagnosis for epileptic attacks of the "epileptic state of absence" type and narcolepsy.

Narcolepsy was described by the French physician /Gelino/ as "a rare neurosis characterized by a suddenly occurring need to sleep, and this desire for sleep is usually short-lived, it occurs more or less frequently, and forces the patient to lie down or even fall asleep in order to satisfy the sudden need for sleep" [60, p 35].

Below we give the observation of N. M. Rudnyy where a state of sleepiness which developed during operator activity had to be differentiated from an attack of narcolepsy and epilepsy. The instructor pilot B, in carrying out a route flight with a student, suddenly stopped answering the student's questions over the intercom. The student who had not soloed before came in for a landing. Before landing, at an altitude of 200 meters, after the flaps had been lowered, the instructor took command of the landing. A medical examination under stationary conditions with the recording of electroencephalograms and various stress tests did not show deviations in the pilot's state of health. As it turned out, on the night before the flights the pilot had slept just four hours. Recently before this flight, he had been intensely involved in flying. The brief shutting off of consciousness was explainable in the insufficient rest on the night before and in the great strain in the preceding days. This, in the opinion of the specialists had caused the development of sleep under the conditions of a monotonous situation [182].

[1]Paroxysm--an attack or onset of suddenly-appearing pain.

The given clinical observation makes it possible to judge the difficulties of a differential diagnosis of paroxysmally arising loss of consciousness under conditions of monotony from narcolepsy and epilepsy.

Pilot V, born 1922. No contusions or head wounds. In the spring of 1944, while walking along the street, he suddenly felt bad, mild nausea appeared, and his temples were throbbing. For a short time his thoughts were uncontrolled. It seemed that passers-by began to walk more quickly and speak more quickly. He continued walking. A short time later he felt a noise in his head, after which he began to feel all right. In April 1946, also suddenly while walking, he felt a mild nausea, noise in his head, and the flow of his thoughts accelerated. He was able to sit down on a bench, after which he lost consciousness for a short time. Upon regaining consciousness, he found himself seated in the same position. In September 1946, after the same warning signs he again lost consciousness for a short period of time during a flight. When he came to, he found that the aircraft had significantly dropped in altitude and was off course.

In an examination, no pathologic symptoms were discovered in the nervous system. Psychopathologic character traits were not discovered. Epileptoid bioelectrical activity was discovered with the recording of the EEG.

Against the background of a normally expressed alpha rhythm in the anterior areas of the brain, clear rapid discharges of an epileptoid character appeared. The given case clinically was assessed as latent epilepsy with attacks of the "absence" type [52].

While an epileptic attack can be excluded using the data of electroencephalography, an attack of narcolepsy is much harder to differentiate from the paroxysmally developing sleep under monotonous conditions, as, for example, in the observation of N. M. Rudnyy. This difficulty is related to the fact that in terms of the EEG picture and the external manifestations, a narcoleptic attack is virtually indistinguishable from the manifestation of natural sleep. In this sleep, as in ordinary sleep, there are dreams. A person who is sleeping during the attack can be awoken. In this regard, a number of researchers have proposed that the essence of the affliction with narcolepsy consists in the unusually frequent activation of the sleep mechanism under inadequate conditions, and this has an insurmountable character, and not the formation of pathologic neurodynamic structures which cause such a state.

In a number of instances, operator activities under monotonous conditions in a way "manifest" the existence of this illness in man. At present, several instances have been described of the brief loss of consciousness in operators of a narcoleptic nature.

In their EEG research, A. A. Genkin, V. P. Danilin and L. P. Latash have shown that the essence of the stable defect of function with narcolepsy consists in a constant drop of the level of brain activity characterizing a state of awakeness at rest in the narcoleptic, in comparison with that level determining wakefulness in a healthy person. This level is not a statically fixed amount, but changes periodically and fluctuates in line with the effects of the external and internal environment which displace it from the necessary (optimal) value and with the intervention of regulation processes aimed at restoring it to the given value. In healthy persons, with a sufficiently high level of wakefulness, under ordinary conditions such fluctuations as a rule, do not lead to periodic falling asleep during the day. With narcolepsy, the stable decline in the initial level of awakeness leads to a situation where these regulation fluctuations cross the boundry between awakeness and sleep (that is, the sleep mechanisms are activated) and cause the corresponding onset of sleep during the daytime. In all probability, the same thing, but in the reverse direction, characterizes the level of the depth of nighttime sleep, and in line with this the fluctuations of this level with narcolepsy lead to the very typical and frequent awakenings of the patients at night.

V. I. Lebedev and O. N. Kuznetsov, under the conditions of an experimental monotonous situation modeling operator activity during a long spaceflight repeatedly observed how in certain subjects, interruptions in operator activity caused by the development of sleep arose paroxysmally. This attack of paroxysmally arising sleep lasted just 30-50 seconds according to the EEG data and stopped just as suddenly [107].

During multiday uninterrupted experiments conducted with a sharp limitation of the flow of external stimuli under the conditions of a monotonous situation (in an isolation chamber), V. I. Myasnikov [155, 156] showed an unique dynamic of bioelectric activity in the brain of the subjects. He established that under the designated conditions, in healthy young persons there was a drop in the amplitude of the alpha rhythm of the initial EEG, the latent period of exaltation of the alpha rhythm increased after exposure of light stimuli, and exaltation itself assumed a stagnant character. All of this showed the development of checking processes in the central nervous system. According to the data of the same author who studied the activity of the subjects under changed conditions (work at night, sleep during the day which is often observed in the profession of operators), under these conditions the development of a drowsy state during an awake period had an influence on the quality of the sleep (on the EEG a decline was noted in the amplitude of the biopotentials and the appearance of diffuse slow waves). Sleep became shallow, and the subjects could not fall asleep for a long time. Analogous results were observed by A. N. Litsov in our experiments [107].

On the basis of these data, O. N. Kuznetsov and V. I. Lebedev have advanced the proposal that under the conditions of a monotonous situation, particularly with an altered sleep and awake regime, the pathophysiological mechanisms of narcolepsy are simulated (a redistribution of the levels of awakeness and sleep). All that has been said, we feel, convincingly shows that the problem of combating monotony in standing watch at the controls of an interplanetary spacecraft is of great significance.

What measures for preventing the development of sleep inhibition have been discovered at present?

In the book "Psikhologiya i Ekonomicheskaya Zhizn" (Psychology and Economic Life), H. Munsterberg in 1914 for the first time pointed out that there are significant individual psychological differences in the effect of a monotonous situation on people. This research based by him on experimental research has been subsequently substantiated by the work of many researchers. In particular, I. P. Pavlov in his famous experiments in the "silence tower" established that dogs with a sanguine temperament are the quickest to fall asleep under monotonous conditions.

One of the measures for preventing a loss of vigilance during operator activity is the carrying out of psychological selection. In the opinion of V. N. Pushkin and L. S. Narsesyan [180], the use of the "running ribbon" method can substantially reduce the number of accidents in operator professions involving the loss of attentiveness. As practice has shown, isolation chamber testing is one of the dependable methods which determine the stable ability to work under the conditions of a monotonous situation. The creation of such conditions which would prevent the development of sleep inhibition is another direction in combating this undesirable phenomenon. Here, of interest are the experiments of the American researchers MacKenzie and Hartman who studied the ability of subjects to work in the cabin of a space simulator. In the course of the experiments, the subjects were given individual signals to which they were to reply in a certain manner. And if the signals came at a rate of 3,600 an hour, the phenomena of a clear overload of the operator with information were observed. At a rate of 350-400 signals an hour, the operator worked normally. But when the rate was dropped to 40 signals an hour, the operators began to work significantly more poorly, and the missed responses to the signals increased [135].

In the work of N. D. Zavalova, B. F. Lomov and V. A. Ponomarenko [69], the following approach was proposed to the problem of operator reliability under the conditions of a monotonous situation. The basic function of the operator in the "man-automaton" system is to assume control in the event of the failure of the automation. But, as was pointed out above, the possibility of the man to effectively interpose himself in the control process depends substantially upon his readiness to carry out the necessary actions, and this under a monotonous situation declines sharply. An unexpected or sudden signal under these conditions often causes a state of stress, with a disruption of thought processes. For the purposes of constantly maintaining a readiness to act, the authors have proposed the principle of the active operator. In their opinion, the operator should continuously receive information both on the basic parameters of the system as well as on the surrounding situation and the course of solving control problems, that is, a portion of the functions of the automatic devices should be turned over to the operator. On the basis of carried out control research on the activity of a pilot in an automated flight, the authors conclude that the fulfilling of the principle of the "active operator" levels off the effect of the emergency situation and helps to reduce emotional tension and maintain work efficiency.

An equally important direction in maintaining a readiness to act on the part of the operator is control over his state. E. Bena et al writes that at present a "vigilance indicator" has been developed which prevents a driver from falling asleep at the wheel. The action of this instrument is based upon the continuous recording of the tension of the eyelids. When muscle tension becomes below a certain amount corresponding to the state of awakeness, a signal device is tripped. In 1971, it was announced that scientific coworkers at Szeged University had designed an instrument which recorded the degree of driver fatigue. When the driver is very tired and begins to fall asleep at the wheel, the instrument activates a warning signal. If the driver does not respond to it, the instrument itself shuts off the ignition system and the engine and vehicle stop.

It is also known that in executing a sharp dive, acceleration occurs and in instances of the effect of great overloads, the pilot can lose consciousness. A series of electrophysiological research has established that as soon as a person begins to lose activeness, slow waves appear in his EEG. This phenomenon in aviation has been used in the following manner. Electrodes connected to an EEG carried on the aircraft were placed beneath the pilot's helmet. When slow waves began to appear on the EEG, a special device converted them into command signals, and an automatic pilot is activated which brings the aircraft out of the dive without the participation of man.

B. F. Lomov and A. I. Prokhorov [144] feel that control over the maintaining of the operator's readiness to act should be devised according to the following schematic system: man (his state)--the device recording biological pulses, the device which differentiates the pulses showing the loss of vigilance--the signal bringing the operator to a state of readiness to act. The development of such a system in practice still presents certain difficulties, but if it is considered that modern electronic technology is continuing to develop rapidly, in all probability, by the time of an interplanetary flight, such a system will be embodied in a dependable device.

Aside from introducing means for monitoring the state of the operator's readiness to act and the rationalizing of his activities at the controls, it is essential to determine the time for standing watch at the central command post. The problem is that at present we can state that with a complicating of work activities and an increase in the duration of space flights, a reduction in work efficiency is observed in a number of instances. This can be seen from the requests of the American astronauts during the flight around the moon not to carry out several TV transmission sessions to the earth as planned in the program due to fatigue. The development of fatigue can also be seen from the telemetric indicators which transmitted to the earth data of the EEG and other functions of the organism. However, it is still difficult to answer the question of at what stage of continuous activity fatigue does arise. Moreover, this is rather individual. For this reason, we are again forced to turn to the experience of operators who work in different systems in the air and on the ground.

A. I. Kokolov [85], in studying working and resting conditions for persons working at a control panel in a television studio discovered that the indicators of the physiological functions reflect a positive adaptation during the first 3 or 4 hours, after which a progressing decline in work efficiency occurs. The research of the foreign psychologist /Mevid Jens/ established that during highly intensive and long flights, the normal length of work for a radio operator equals 3 hours. With a greater length, according to his data, the work indicators deteriorate progressively, and tension and irritability rise. The study of V. V. Suvorova, et al. of the experience of persons on duty at modern automatic electric plants indicates that these periods of duty lead to exceptional nervous stress. Numerous data of Soviet and foreign scientists show that after 5-6 hours of watching, a person's vigilance begins to decline, and, respectively, his reliability as an element in the "man-automoton" system also declines. The researchers have pointed out that negative emotions also have a great effect on the development of fatigue. If it is considered that on a spacecraft a number of unfavorable factors will be present, including the great length of the flight, obviously it must be expected that fatigue during a space watch will develop sooner than after 5-6 hours. As research has shown, the most optimum period of work will be a time not exceeding 4 hours (with compulsory preliminary active rest and sleep). Experimental research to some degree is substantiated also by the practice of long submarine cruises where the sailors stand a 4-hour watch.

An analogous conclusion was reached by the American researchers /A. A. Alluesy, D. D. Childs/ and others working in the area of space medicine [218a, pp 163]. The daily schedule of the cosmonauts will include time allocated for conducting scientific research. During this time, various observations and experiments will be made, and the obtained results generalized.

Active rest will be full of physical exercises, listening to musical performances, viewing films and TV broadcasts, and so forth, as was described by us above in detail. The rhythm of sleep and awakeness assumes great importance for maintaining work efficiency during a space flight. Let us examine this problem in greater detail.

The Rhythm of Sleep and Awakeness in a Spaceflight

> It is essential to understand what man is, what life is, what health is, and how equilibrium and a harmony of the elements supports it, and how their disharmony destroys it.
>
> Leonardo da Vinci

The first person who fell asleep in space was G. S. Titov. After the flight, he said: "At 1815 hours, Vostok-2 passed over Moscow....The time from the evening of 6 August until 0200 hours on 7 August had been assigned to me for rest and sleep....I closed my eyes and fell asleep....I was awakened by a certain strange state of my body. I could see that my arms were over my head and hanging in air. It was the state of weightlessness. I had fallen asleep with my hands under the strap, and I looked at the display board of a special counter which indicated that the ship was in its eighth orbit. I awoke again on the tenth, and again on the eleventh orbit, I looked at the display and again fell asleep...I was to finally wake up and begin working at 0200 hours on 7 August. But I slept an extra 35 minutes. This was understood on the earth, and they did not wake me, allowing me to rest a little better....I woke up feeling fresh and wide awake....I did not have any dreams and slept like a log...." [199, pp 110-111].

That sleeping in a state of weightlessness is uncomfortable was described by G. T. Beregovoy after a flight on the Soyuz-3 spacecraft: "The impressions from all that I experienced during the first day of my space odyssey were rather rich, and I virtually did not sleep during the first night in space. Moreover, one other not unimportant factor was at play in my insomnia, and that was the very state of weightlessness. Weightlessness is one thing under ground conditions, in training, just several score seconds, but something quite else when the weightlessness is extended, and so to speak, stable. It is rather difficult to fall asleep under such uncustomary conditions. The free floating in the air, as it turned out, is not the most comfortable bed, althouth it is certainly the softest. Such "softness" is totally useless. For example, if you move your leg while asleep, then immediately, by the principle of reactive force, you float off to the side. And to float means to wake up. For this reason, ultimately you find yourself with what, at first glance, is a strange wish: to swaddle yourself, to wrap up, so to speak, like you were when you were little. But swaddling does not come in the supplies of a spaceship. There are straps instead of swaddling. Hence you try to "swaddle" yourself without the swaddling, and to hold yourself down somehow in space. You stick your foot into some slot between the equipment, hold onto the straps and hopefully you can fall asleep. But once you have fallen asleep, you sleep less but sleep better. There is no strain on the joints, on the muscles and all the rest..." [13, p 302].

Other cosmonauts have "floated out" of their sleeping bags during sleep. "Once du 'ng sleep it grew hot in the ship," wrote A. G. Nikolayev, "and I loosened the fastenings of my sleeping bag. Due to accidental motions with my hands and feet and turning over in my sleep, I floated out of the sleeping bag and without waking up, began to float freely around the ship. When I woke up, in the darkness I at first could not figure out where I was, and when I turned the lights on in the cabin, only then did I understand that during my sleep I had merely floated out of the bag and found myself on the ceiling....I always slept well in space. Your sleep is deep. It lasts at least 7-8 hours a day. During sleep, my pulse dropped to 43-45 beats a minute, and respiration to 10 times a minute. We rarely woke up. Sometimes we had good dreams. They were in black and white. Physicians say that there are also dreams in colors, but we did not have any. Dreams in color are of interest to specialist physicians, and for this reason they asked what dreams we had; black and white or in color? I repeat, we had only black and white dreams. We always slept well. After sleeping we felt rested, cheerful, fresh and experienced an influx of new energy" [160, p 107-108].

In the diary of G. T. Dobrovol'skiy of 7 June 1971, we find the following entry: "Vadim and I slept with our head down in the sleeping bags in the orbital module. Viktor was in the device which could be lowered down across the seats, and also in a sleeping bag. I slept less than usual (from 1830 to 2400 hours), but my impression is that I slept enough" [63, p 19]. V. N. Volkov on 26 June 1971 in his diary noted: "It is the 21st day of the flight. Our sleeping places for some reason remind me of hives where bees are kept. There are also small openings into which we float when the time comes to sleep, and from which we float out when the command for waking up rings.(this means that the person on duty wakes you by tapping you on the shoulder and sometimes on the head). A word about sleep. For some reason these two days I have slept very poorly. All in all I have slept just about 3 hours. During the last flight I did not have any dreams. This time there are dreams seemingly constantly, even more than on the earth" [31, pp 137, 139].

Above we said that the creation of artificial gravity during an interplanetary flight will eliminate the discomfort of sleeping in a state of weightlessness, And probably in this state the phenomenon of "shortened sleeping" will disappear. However, the particular features of sleep in an interplanetary flight go beyond these circumstances.

In the process of the evolutionary development of plants and animals, a number of physiological adaptations evolved to the periodic geophysical and meteorological changes related to the earth's rotation around its axis. These include: the alternation of the light period and darkness, the increase in temperature and the rise in solar radiation during the daytime, the change in humidity and barometric air pressure at night, and so forth. One of the most characteristic adaptations of such a sort is the daily rhythm of sleeping and awakeness. Here a drop in body temperature, pulse and respiration, metabolic processes and other physiological functions in the organism is noted at night and a rise in them during the day. At present, in man more than 40 different physiological processes have been recorded the expressiveness of which is clearly related to the time of day. Even such phenomena as birth and death are subordinate to the daily periodicity; according to the data of F. Halberg [210], the greatest number of them occurs in the time from 2300 to 0100 hours.

In a spaceflight, the periodics of light and darkness changes substantially. Suffice it to say that in an orbital flight the alternation of "day" and "night" can be rather fast. Thus, G. S. Titov greeted 17 "space dawns" during a 24-hour period. The situation was somewhat different on the Soyuz-9 spacecraft. About this situation, A. G. Nikolayev writes: "In an orbital flight, the spaceship in 24 hours (during the earth's day) flew around our planet 16 times. In one orbit, we had an alternation of night and day, that is, the ship was in the light and shadowy sides of the earth. However, depending upon the time of the flight, the space days and nights can be of differing durations. Thus, in our flight for approximately 3 days (from the third to the sixth day), our ship was flying along the line of the terminator (the line separating night and day on the earth's surface), and for all these 3 days of the flight we were on the light side of the earth. The sun never went behind the horizon. Then it began to set for a few seconds, gradually increasing the time between sundown and sunup. This was a very interesting phenomenon. Under these unusual conditions, we lost the sense of the alternation of night and day and gradually grew accustomed to counting days purely conditionally, and we lived solely by the clock. We worked during the time provided by the schedule, and when the time approached to sleep, we lay down, fell asleep and got up at the set time" [160, pp 108-109].

In an interplanetary flight, though, there will not be the daily and seasonal periodics which are so customary for life on earth. In landing on one or another celestial body, the alternation of night and day will also seem substantially different from the one on the earth (for example, on the moon a day lasts almost a month according to a terrestrial calculation). In line with this, there is the urgent question of how the conditions of a spaceflight will influence the biorhythm of people and within what limits their biorhythm can be readjusted without detriment to the organism.

A study of the biorhythm of living organisms was started more than 200 years ago. In 1729, the astronomer de Meran discovered that in plants which were kept in the darkness at a constant temperature, the same periodicity in the movement of the leaves was observed in the plants kept under the conditions of the ordinary alternation of light and dark during the day. Similar experiments were continued in subsequent years on various levels of an organism, from the single-celled to man. As a result, it was possible to establish that even the simplest living beings kept under the conditions of constant illumination (or darkness) maintain rhythmical fluctuations in activity and rest, growth, division, and so forth. Such rhythms have been termed "circadian" from the Latin words (circa--around and dias--day).

According to the data of numerous researchers, in plants the period of the circadian rhythms is 22-28 hours, and in a majority of animals, 23-26 hours. This pattern is also observed in man. Thus, the results obtained by the foreign scientist M. Lobban [141] who conducted research on Spitsbergen during the polar day indicate that a continuous 2-month daily illumination does not have a marked effect on the circadian rhythm of the physiological functions of persons coming from the middle latitudes and continuing to work and rest under the customary conditions for them.

A. Ashoff [11] in his experiment placed a group of subjects in a specially equipped bunker which was deep under the ground, thus excluding the penetration of sound. The subjects were left completely to themselves. They put out the lights before going to sleep and turned them on upon awakening, they prepared their own food, and so forth. Using a special device, a continuous recording was made of the physiological functions of the subjects. The experiments showed that over 18 days the subjects "lagged behind" astronomical time by 32.5 hours, that is, their days consisted not of 24 hours but almost of 26 hours. Characteristically, a fluctuation of all the physiological functions was observed precisely in this rhythm at the end of the experiment in the subjects.

The French speleologist /Michel Sifre/ in 1962 descended to a depth of 135 meters in the Scarrason ice cave, and spent around 63 days in it. It was totally dark in the cave, and in a tent, where the speleologist spent a significant portion of his time, there was weak artificial illumination. The speleologist lived according to a "free" regime, that is, he went to bed when he was tired and felt like sleeping, and woke up without an alarm clock by himself. He telephoned his comrades on duty at the surface about the time of going to sleep and waking up. On a graph which was kept from his telephone calls, it could be seen that his "days" began to comprise an average of 25 hours.

In 1967, eight Hungarian researchers spent just a month underground in one of the caves of the Buda Mountains. The members of the expedition did not have watches. And when they received the order by telephone to ascend to the surface, it turned out that the time calculations in the cave were [illegible] days behind reality. Here the "biological clocks" for the first 10 days had run synchronously in all members of the expedition, but later on the discrepancies began in time orientation.

Thus, it can be concluded that the circadian rhythm of animals and man is very constant under so-called permanent conditions.

A number of observations and studies shows that an acute disruption of the customary rhythm in the activity and rest of people leads to a marked decline in work efficiency and to a deterioration in the general state of health. This is particularly noticeable in flights over long distances on jet aircraft from the east to the west. A Muscovite, having flown from the capitol of the USSR to Khabarovsk or to Washington, in the new place will go to bed and wake up 7 hours earlier or later than his customary time. Such a change in time zones requires an adaptation in the biorhythm by the human organism in accord with the altered conditions of life. For several days after such a flight, the phenomena of dissynchronism are observed: the physiological cycle of "night and day" cannot be changed in a short period of time, since the internal or indogenic (biological) clock does not coincide with the astronomic local time. For the first several days, the altered way of life of the organism is split into an awake brain and a sleeping body. Then for several days all the physiological processes adapt to the new conditions. And until both cycles, physical and physiological, are synchronized, that is, until they are intercoordinated, a larger portion of the people, particularly the elderly, feel physiological discomfort. At night they often cannot fall asleep, and during the day they are sleepy and out of sorts. A number of scientists feel that at international conferences, important questions should not be discussed or decisions taken during the morning of the first days after a long distance flight in an easterly direction and in the evening after a flight to the west. Observations indicate that athletes during the first days after a flight over four and more "time zones" to some degree get out of shape, and a certain time is required for recovering it.

French scientists [3] have established that too frequent shifts in the cercadian physiological cycle cause stress in aircraft crews who make long distance flights. In 78 percent of the pilots disruptions of the dissynchronosis type occurred in changing time within limits of 4-5 hours. These authors stressed that the adaptation of the organism to such perturbations is very difficult. In order to avoid the development of neuroses in flight personnel, the foreign aviation companies endeavor to organize the work schedule of the pilots considering the cercadian rhythms.

We are interested in comparing the work efficiency and state of health of cosmonauts who have made a flight both under conditions customary for terrestrial conditions and in altered ones. On the American Gemini-5 (a flight duration of 8 days) and Gemini-7 (a duration of 14 days) spacecraft, a terrestrial way of life was observed (8 hours of sleep and 16 of awakeness) coinciding with the hours of sleep and awakeness at Cape Kennedy. According to the reports of the astronauts and the conclusions of specialists, the work efficiency of the crew members was kept at a rather high level, and good sleep was observed. During the flight of the Gemini-4 spacecraft which lasted 4 days, as a consequence of the discrepancy of the sleep period with nighttime at Cape Kennedy, the astronauts J. McDivitt and E. White felt fatigue and lost sleep. C. Berry, in analyzing the reasons for the "unsatisfactory" situation during the flight of the Apollo-8 spacecraft, put among the unfavorable factors not only the effect of weightlessness and other factors, but also a disruption in the sleep and awakeness rhythm. During this flight, the astronauts slept during free time, as they say, between jobs.

During the flight of the Soyuz-3 spacecraft, the hours of sleeping and awakeness during the first days coincided with the local launch time. During the flights of the Soyuz-4 and Soyuz-5 spacecraft, it was 3 hours behind the local schedule, during the flights of the Soyuz-6 and Soyuz-8 ships it was 2 hours ahead, and during the flight of the Soyuz-9 craft, 9 hours ahead (sleep from 0800 to 1600 hours). In the subsequent days, due to the precession of the orbit, the sleep and awakeness schedule during the flights of the Soyuz-3 and Soyuz-9 ships shifted an average of 30 minutes a day.

Analysis of results obtained in these spaceflights made it possible for A. N. Litsov to establish several periods in the dynamics of the functional state and work efficiency of the crews. These are: the first (from 0 to 2 days) characterized by a significant deterioration in the general mood, work efficiency and sleep of the cosmonauts; the second (from 3 to 6 days) with the recovery and subsequent maintaining of the functional state and work efficiency on an optimum level; the third (beginning from the 7th-9th day) with a gradual decline in the functional state and work efficiency; the fourth with a brief rise in the functional level of the basic systems of the organism (the "final burst") related to the task of landing the spacecraft.

According to the data of A. N. Litsov [139], a majority of the EEG of the crews taken in the first days were altered in a direction of the predominance of high frequencies, and this could be related to the high functional level in the work of the cerebral cortex. However, the polyrhythmicness of the EEG with the presence of bursts of slow waves, the phase changes (exaltation and stagnant depression of the dominant rhythm), as well as a deterioration of a majority of the psychophysiological tests show the weakening of both the processes of excitation and the processes of inhibition. According to the data of this author, such changes were less expressed in the crew of Soyuz-3 who used the customary schedule of sleeping and working during the space flight, and somewhat more expressed in the crews of Soyuz-4 and Soyuz-8 which had schedules with slight degrees of displacement, and most expressed in the crew of Soyuz-9, the daily regime of which for a long time was shifted 4-8 hours relative to the usual schedule.

In the fourth chapter, we have taken up in detail those changes in the neuropsychic sphere which were observed in the crew members of the Soyuz-9 spaceship. There is no doubt that one of the many reasons for the changes was also the altered work and rest conditions for the cosmonauts during this flight.

While even in a short spaceflight the consideration of the biorhythmic patterns is of such important significance, it is not difficult to imagine that the rhythm of sleeping and awakeness in an interplanetary flight will to a great degree determine the levels of work efficiency and even the health of the cosmonauts. The high work efficiency of the cosmonauts during a spaceflight can be provided only in the event when living conditions will be worked out which adequately conform to the natural rhythms of the psychophysiological processes in the organism.

Although living organisms are calable of maintaining a cercadian rhythm, this in no way means the inevitability of the maintaining of its parameters under any conditions of life. Certainly an organism is an "open system," and it is constantly under the influence of surrounding conditions, and adapts to their changes. A large number of experiments shows that under isolated conditions, light and temperature have the basic effect on reorganizing the rhythm of the physiological functions of animals and plants. The experiments of O. P. Shcherbakova [227] conducted on monkeys are valuable for the study of the adaptation of physiological functions in the higher animals to changes in the rhythms of vital activity. The experiments were conducted during the year in a specially equipped house with artificial lighting. The physiological functions were studied with a two-phase, shortened, lengthened and other daily regimes. For example, it turned out that in establishing a two-phase daily rhythm, in a majority of the monkeys, on the third day the corresponding rhythm of motor activity arose, and then on the sixth-thirteenth day, a two-phase temperature curve, respiration rate and pulse were also formed.

In an interplanetary ship, an artificial environment will be created in which it will be possible to regulate the effect of such factors as light, temperature, the background sound, and so forth on man. For this reason, of great interest is a study of the rhythm of sleep and awakeness under the conditions simulating a spaceflight for the designated parameters. In the USSR, a study of the effect of altered conditions of daily activity on the human organism under the conditions of isolation was started by V. I. Myasnikov in the laboratory of F. D. Gorbov.

O. N. Kuznetsov, V. I. Lebedev and A. N. Litsov [109] have conducted experiments under the conditions of an isolation chamber to study the various regimes of daily activity under the conditions of an isolation chamber. Participating in the experiment were men from 26 to 38 years of age who had undergone a complete clinical examination. We studied the following regimes: conventional (work during the day, sleep at night); reversed (work at night, sleep during the day), and broken with a repeated alternation of periods of awakeness and sleep during the 24 hours. During the period of awakeness, the subjects carried out operator activities and rested actively.

Fatigue was judged from the results of operator activities and special psychophysiological research. The depth of sleep was assessed on the basis of both objective and subjective indicators. The objective indicators included: visual observation using infrared equipment; listening to sounds in the chamber; analysis of the actographic recordings such as the percentage of peaceful 5 minutes (PPF) of the total number of 5 minutes and the duration of the interval of quiet; analysis of pulse and respiration rate, as well as bioelectrical activity of the brain (EEG). The subjects stated their subjective sensations in their reports as well as in the entries of their diaries.

At first we conducted 8 extended isolation chamber experiments with the usual schedule of daily activity. With the normal conditions, all of the 8 subjects slept well for the period of isolation, they maintained the typical changes for ordinary conditions, as well as the alternation of deep and superficial sleeps (in falling asleep the PPF was 75-90 percent, and upon awakening reached 60-70 percent). The duration of sleep in a majority of the subjects did not exceed 7 hours per day. Fatigue with orginary daily activities developed more slowly than with the reversed or broken conditions.

In the experiments with the reversed daily schedule, there were 6 perons involved. During the first days of the experiments, the development of drowsy states during the period of awakeness was observed in the subjects. In going to sleep, it took a long time for the subjects to fall asleep, and if they did fall asleep, the sleep was not always complete. We will give the diary entries of subject B who participated in the experiment with a reversed schedule.

The first day: "I went to bed at 1400 hours. All in all, I slept around 3-4 hours after taps and before getting up. The remaining time I merely lay calmly. There was no anxiety or disturbance." The second night: "I slept well, peacefully, even regardless of the fact that I evidently tossed and turned. I got up in a good mood, did my exercises and for this reason, probably, feel sleepy." The third night: "The only thing that differs from the schedule is that I sleep little, during the second night I woke up at 1800-1900 hours and could not get back to sleep or even drowse. I simply did not feel like sleeping, and got up cheerful in a good mood." Fifth night: "Again I did not sleep very soundly. I awoke well before 1700-1800 hours, and after that half dozed. But still each time I get up cheerful and happy. I could still 'use' an hour of rest which I have set for myself." The sixth night: "Sleep yes, not quite sound, but normal. I really sleep little. and the remaining time is in half dozing. This does not tell on my general state. I do not want to sleep 'during the day' obviously because of nerves. I will probably feel the fatigue after leaving here." Seventh night: "Again I got up not very cheerful and was even tired (the seventh day) or felt poorly. I did not sleep very calmly." Ninth night: "I slept well" [107, pp 247-248].

In the experiments of V. I. Myasnikov [156], the subjects with a reversed schedule experienced a sensation of fatigue which was accompanied by a decline in activeness in fulfilling the experimental psychological tests as well as by a whole complex of changes in the EEG. The bioelectrical activity of the subject's brains, according to his data, in the experiments with the usual schedule of daily activity in 60 percent of the cases was characterized by a reduction in the amplitude of the alpha rhythm on the initial EEG. In the experiments with the reversed schedule, from the second-fifth day, the EEG showed a reduction in the amplitude of the biopotentials and the appearance of difuse flow waves. The alpha rhythm index in the experiments with the usual daily schedule changed insignificantly, dropping to 2-15 percent of the initial level by the end of the research. In the experiments with the reversed schedule, the alpha rhythm index dropped significantly, by 13-33 percent during the first days, by 61-90 percent on the fifth, and 82-99 percent on the tenth-fifteenth day of the experiment.

In our experiments (according to the data of A. N. Litsov [140]), during the first-third day with the reversed schedule, the dynamics of pulse and respiration rate, as well as body temperature maintaind the sine curve of the usual schedule (the average values of the studied functions were higher during the daytime hours during the sleep of the subjects and lower during the nighttime hours while awake). Beginning with the second-third days, in the dynamics of these functions, changes began to occur with a gradual rise in the indicators during the nighttime hours of the day while the subjects were awake, and a decline in them during the daytime while asleep. For pulse and body temperature, this process ended on the fourth-fifth day, and for respiration, on the sixth-seventh day.

In contrast to the autonomic functions, the EEG dynamics came into accord with the new conditions significantly more rapidly. Thus, even during the first day of the reversed schedule (regardless of the nighttime hours), while the subjects were awake, alpha and beta rhythms and low values of general energy prevailed, showing the high level of the functional activeness of the brain cortex. In going to sleep and during sleep (regardless of the daytime hours), in the EEG of the subjects, on the contrary, there was a clear redistribution of the basic rhythms in the direction of the predominance of slow waves and an increase in the general energy of the EEG, and this characterizes the low level of the functional activeness of the cortex. However, while awake, in a majority of the subjects, during the first-third days of the reversed conditions, the amplitude of the slow waves was lower and the energy of the quick EEG potentials was higher during the daytime hours than at night. On a general EEG during this period one can often see individual or group slow waves, polyrhythmicness of the EEG, exaltation of the alpha rhythm or its depression. These EEG changes were more often noted during the nighttime hours (when the subjects were awake), and, as A. N. Litsov feels, were related to the development of drowsy states.

In contrast to the normal schedule whereby work efficiency declined only at the end of the active period (in the evening), during the first days of the reversed schedule, a decline in work efficiency was noted in the subjects immediately after their awakening (at 2300 hours) and remained for several hours during the nighttime. At the end of the active period (at 1100 hours), the work efficiency of the subjects began to rise. In the subsequent days, work efficiency improved. The different indicators of work efficiency, like the physiological functions, changed over the course of the research in a dissimilar manner, that is, the simple motor reactions and the reactions of stopping a moving target began to conform to the new conditions on the second-third day, while the reaction of choice and resistance of a given activity to interference of a signal character, using the method of F. D. Gorbov, occurred on the fifth-eighth day. In the process of the reorganization of physiological functions and work efficiency, the subjects complained of lethargy and sleepiness, and of increased fatigue and a reduction in work efficiency.

Analysis of the experimental data with this schedule makes it possible to establish that the character of changes in the physiological functions and motor activeness during the sleep of the subjects differed significantly from the usual. Thus, motor activeness during the first three days for all periods of sleep was rather high (PPF of around 50). For the pulse and respiration rate at this time, sharper fluctuations were characteristic not endemic to the changes of these functions during normal sleep. On the first day, the EEG dynamics also differed from the ordinary. Although in going to sleep, as under usual conditions, there was a significant increase in the total energy, the fast EEG components (the alpha and beta rhythms) declined and the slow ones increased; bursts of alpha rhythm usual for sleep were not noted. During the first days with the reversed conditions, clearly delimited stages of sleep were not noted. From the individual indicators it was difficult to establish the periods of falling asleep. Periods of deep sleep were rarely noted and alternated with extended periods of superficial sleep or its absence. The results of observation using infrared radiation showed that for a long time the subjects lay with their eyes open with the lights off. All of this showed that during the first days of the reversed conditions, sleep was less deep. However, as the subjects became accustomed to the isolation chamber, both the objective and the subjective data showed a gradual improvement in sleep (by the fifth-sixth day, the total duration of sleep averaged 75-80 percent of the time allocated for it).

A. D. Slonim and G. M. Cherkovich in experiments on animals established three stages in the readjustment of the biorhythm. Analogous stages have also been noted for people.

The first stage is characterized by the maintaining of the old daily biorhythm stereotype for the first 3 days. This period is the latent stage of readjustment. The second stage, in lasting from 2 to 7 days, is characterized by a gradual shift in the physiological functions, work efficiency and sleep of the subjects in a direction of corresponding to the new conditions. This is the stage of visible readjustment. The third stage is characterized by a reinforcing of the new daily stereotype which appears in the preceding stage; this is the stage of profound readjustment.

As a whole, for animals, in readjusting the daily regime, physiological effects (light, temperature, and so forth) were of basic significance, for man, as O. N. Kuznetsov has rightly stressed, psychic activity, the volitional effort to carry out the daily schedule, and the ability to quickly reorganize oneself in accord with the changed situation were crucial. We have established that the adaptation of physiological functions to the new rhythm is particularly difficult for those persons who constantly tried to imagine what was happening at the given moment of the day outside the chamber.

In the experiments with the double alternation of sleep and awakeness during a 24-hour period, seven persons were used. The subjects were divided into two groups. The daily schedule of the first group consisting of three persons provided two periods of sleep of 4 hours each (from 2300 to 0300 and from 1400 to 1800 hours). The schedule of the second group consisting of four persons provided sleep from 1000 to 1600 and from 2300 to 0100 hours.

According to the data of A. N. Litsov, in the first group of subjects during the first 3-5 days, one could note the phenomena of an internal dissynchronosis of the rhythms. Analysis of the experimentsl data showed that during the first days, the subjects slept well in both intervals. Due to the fact that the first sleep started, as usual, at 2300 hours, the subjects fell asleep rather quickly (in 10-30 minutes), and the dynamics of sleep in relation to the stages of the EEG and their development, corresponded to the usual daily schedule. The second sleep (from 1400 to 1800 hours) during the first day was also good. The subjects comparatively quickly (in 15-40 minutes) fell asleep, the sleep was deep, and lasted 3-3½ hours. However, the deepening of sleep occurred more quickly than during the nighttime hours (60-80 minutes), and was accompanied by a clear predominance of the paradoxal phase.

Beginning on the second day, three consecutive stages could be traced in the sleep dynamics of the subjects. The first (second-third day) was characterized by a sharp deterioration of sleep in both intervals. For all the subjects, the time taken to fall asleep increased (up to 120-150 minutes), the deepness of sleep declined and its total length dropped to 4-4½ hours. For the second stage (fourth-sixth day), there was a characteristic alternate deterioration or improvement in sleep in both intervals. The third stage (sixth-tenth day) was characterized, on the one hand, by a significant improvement of sleep during the daytime and an increase of its duration to 5-6 hours at the expense of free time, and on the other, by the use of only the second half (from 0100 to 0300 hours) of the nighttime interval for sleeping.

The deterioration of sleep and the dissynchronization of physiological functions had a negative effect upon the dynamics of work efficiency. The indicators of operator activity worsened, reflecting the difficulties in adaptin to the given conditions. The subjects during the ninth-eleventh days had not adapted to conditions with two 4-hour cycles of sleep, and by the end of the experiment had independently changed over to similar conditions but with an uneven distribution of the "sleep-awakeness" cycles (awake from 0300 to 1200 and sleep from 1200 to 1800 hours for the first cycle, and awake from 1800 to 0100 hours and sleep from 0100 to 0300 hours in the second cycle).

The particular features of adaptation detected in the first group of subjects served as the reason for arranging experiments under conditions with an uneven distribution of the "sleep-awakeness" cycles, but with the maintaining of all the remaining elements of the daily schedule unchanged. As these experiments showed, the curves for pulse, respiration and body temperature under these conditions, although generally similar to changes in the first schedule, in contrast to it, more quickly assumed a "double-hump shape." Two maximums and two minimums were observed in the dynamics of the basic EEG rhythms from the first day. On the EEG of the first two days one could note bursts of slow waves and exaltation of the alpha rhythm (phase shifts). This shows a general decline in the functional state of the higher areas of the central nervous system. In contrast to the first schedule, these changes in higher nervous activity of the subjects were less expressed and more rapidly (on the second-third day) disappeared.

With the second daily schedule, on the first days, disruptions in the subject's sleep were also noted. In the subsequent days, the duration of sleep in the scheduled time rapidly increased, and in terms of the character of the distribution of the stages, approximated sleep under the ordinary schedule.

With the second schedule, disruptions in work efficiency were also noted. However, the changes in a majority of the psychophysiological tests under these conditions were insignificant, and basically concerned only the nighttime period of the day. A deterioration of the indicators was observed predominantly in the dynamics of complex tests (time tests, solving mathematical problems at a set pace, and choice reactions), at the same time that simple motor reactions and reactions to a moving object and so forth virtually were unchanged. The restoring of the typical dynamics of work efficiency in a majority of the subjects occurred approximately on the third-fifth day.

Proceeding from an analysis of the material of these experiments, A. N. Litsov has concluded that the dynamically observed deviations in the physiological functions were insignificant and disappeared more rapidly than with the first schedule, and this indicates a preference for the given schedule in comparison with the first [140]. The same conclusion was reached by B. S. Alyakrinskiy who writes: "As is known, during the working day, labor productivity, as a rule, declines unevenly from the first to the last hours of work, but according to a 'double-humped curve.' Graf called such a curve the 'physiological curve of work.' The first maximum on this curve is noted in the morning, and a second in the afternoon. Ashoff, in characterizing the phenomenon of a double phase in the daily rhythm of living systems, has introduced the concept of bigeminous. He showed that the two-humped curve is inherent in fact to all functions of the organism. A correctly organized schedule of labor and rest should reflect the bigeminalnous of primarily the external activeness of the organism" [4, p 57].

In the experiments with a triple alternation of the sleeping and awakeness cycles, 16 subjects were involved. In this research, three variations for scheduling the cycles were carried out. This research showed that the readaptation of the autonomic functions with these schedules occurred significantly more slowly, and had not ended by the end of the tenth-twelfth day.

Subjectively, the subjects noted difficulties of remaining awake at nighttime, and this for a certain time caused unpleasant sensations (sleepiness, lethargy, and so forth). In individual subjects this state lasted almost to the end of the experiment, although sleep had normalized by the seventh-eighth day.

As an illustration, we will give the diary entries of subject V with the 3-cycle daily schedule. First night: "During the period from 0200 to 0500 hours, I particularly felt like sleeping, since my organism had not yet adapted. Will it be better? During the daytime, I wanted to sleep, and my state was lazy and feeble." Second night: "From 1300 to 1600 hours, I absolutely did not want to sleep, and I just lay there." Fourth day: "Again I slept very poorly at night, and during the day I was sleepy. Apathy for physical exercises appeared." Fifth day: "The broken schedule is eating, drinking and sleeping. It would be better if...sleep were an hour and a half more, and less for the remaining." Sixth day: "Today I did not want to get up according to the schedule, and evidently the systematic lack of sleep during the day is telling" [107, p 248].

It is interesting to note that certain subjects with the broken schedule experienced the illusion of the accelerated passage of time. Thus, in the diary entries of subject V we read: "18 November 1967. Second day. Time passes as usual. No negative emotions, except a slight disappointment that I am not doing everything correctly. In the next free time, I will draw up a detailed daily schedule. 23 November. The broken schedule greatly reduces the sensation of the duration of the day. Instead of a day you have three toy-like pieces of time: you jump out of bed, trifle away your time in the dark, eat, write a few lines and go to sleep. Three such rounds and there is no day. For me, the four days of the broken regime passed almost as fast as the first two of an ordinary regime. You have the impression that unnoticed several pieces of time have been cut out of the day and discarded. 24 November. After having gotten accustomed to the interrupted schedule, time passes more quickly, or more accurately, the pace is the same but the day seems 50 percent shorter. The eighth day is now coming. Of them, the last four have passed more easily and more quickly than the first. 26 November. Of the previous experiment, only the general reduction in the scalar perception of the day as a whole has remained. A day under ordinary conditions involves many matters and impressions. A day in an isolation chamber is condensed like milk in a can. It is emotionally less vivid" [135, p 170].

A comprehensive examination of the change in sleep under different daily regimes, along with the study of work efficiency, has made it possible to analyze the difference in the subjective difficulties in adapting to the reversed and broken regimes. With the reversed conditions, the person was forced to work during the usual hours for sleeping. This is difficult due to the inertia of the evolved diurnal stereotype. However, the continuity of the periods of sleep and awakeness is a positive factor in these conditions. With the broken conditions, the basic subjective difficulty is that the alternating of the working day and nighttime sleep of sufficient duration is interrupted or totally disappears. The more the rhythm of human vital activity differs from the customary, the more poorly he stands this. On the basis of the research described by us as well as the published materials, the following conclusions can be drawn.

The rhythm of human vital activities, in accord with the necessity of standing watch and carrying out other functions on an interplanetary ship, can be changed. However, the "space days" in an interplanetary flight should not go beyond the limits of terrestrial days. In organizing the daily schedule on a spaceship, it is very important to establish permanent hours for standing watch, for active rest, and for sleep for each crew member. This demand is dictated by numerous experiments of I. P. Pavlov who pointed out that the maintaining of the stereotype day in and day out requires less and less "nervous expenditures." The precise fulfillment of the daily schedule over time becomes a signal for the rapid development of sleep and for providing balanced rest. "A strictly maintained order in the alternation of awakeness and sleep," wrote I. P. Pavlov, "the established rhythm can increase the persistence of sleep and without sufficient fatigue of the cortex" [166a, p 278].

The experience of the 8-day flight of the American Gemini-5 ship showed that it is very difficult to sleep in turns in the work area. The astronauts

G. Cooper and C. Conrad complained that the slightest noise, even the leafing through of the ship's log, woke them up, since it was very quiet in the cabin.

In the third chapter of this book, we have written that on an interplanetary ship, it is essential to have separate quarters for the rest of the crew members. For maintaining the set rhythm on the spaceship, it will be essential not only to strictly observe the schedule, but also to create systems of artificial time sensors in the work areas and rest areas. New experiments on the earth as well as the experience of living on long-lived orbital stations undoubtedly will make it possible to clarify the optimum rhythms for a space day in an interplanetary flight.

CONCLUSION

> There can be no doubt that the time is not far off when the crew of mighty spaceships weighing many tens of tons equipped with all sorts of scientific equipment will leave the earth and head out on a long voyage...to Mars, Venus and other planets.
>
> S. P. Korolev

12 April 1961 will go down in history forever as the day of the start of the era where man conquered space. This event was the embodiment of the collective efforts of many Soviet scientists, designers, workers, engineers and technicians. The Vostok satellite spacecraft developed by them made it possible for the courageous cosmonaut Yu. A. Gagarin to make a historic flight into space. This significant success in conquering space was continued and developed by the orbital flights and the flights to the moon by Soviet cosmonauts and American astronauts.

But still we are not aware of the entire greatness of what has happened, since these are events of the very near past. "But we live," wrote Yu. A. Gagarin, "in unusual times. The wind of wanderings, like four centuries ago, is filling out the sails of the 'space caravelles' ready to set off for the distant and unknown shores."

At present, mankind is actively preparing for interplanetary flights. The technical, biological and psychological problems are being worked out on a broad front, and enormous experience has been acquired in the vital activities of man under the conditions of a spaceflight and in simulator experiments. On the basis of a generalization of the materials relating to the psychological features of the activity of cosmonauts under the conditions of space, we have endeavored to glance into the not so distant future and spot certain psychological problems of an interplanetary flight.

But enormous difficulties must be surmounted on the way to realizing interplanetary flights. The pending difficulties on the threshhold of spaceflights was clearly seen by the founder of cosmonautics, K. E. Tsiolkovskiy, who wrote: "Undoubtedly, success will be achieved, but...the notion of the ease of solving it is a temporary deception....If the difficulties were known, many persons working with enthusiasm would dismiss the matter in terror. But on the other hand how fine the achievement will be!"

There can be no doubt that whatever the difficulties await the people participating in the conquering of space, all obstacles will be surmounted and interplanetary flights will become a fact.

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